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Supracondylar Fractures of the Humerus in Children Operative Treatment

Dwight A. Jacobus, D.O., Dayton, Ohio

ABSTRACT: Supracondylar fractures represent the most common fracture about the elbow in children at the 5 to 10 year age group. Failure in treatment usually stems from technical failure. Loss of reduction after manipulation is usually due to inadequate flexion in the splint or cast. It is our experience, that unless the elbow is flexed to at least 120° or more, with appropriate pronation or supination, the physician frequently loses stability. If flexion causes neurovascular compromise, another type of management has to be considered. In this situation, open reduction, internal fixation or percutaneous pin fixation is mandatory. If satisfactory reduction is not obtained before attempted percutaneous pin fixation, it will probably result in failure. Percutaneous pinning should be used in those cases where anatomic reduction has been obtained. The most frequent angular deformity is cubitus varus which is the result of medial tilting of the distal fragments. Medial tilting of the distal fragment is a direct cause of cubitus varus. Medial rotation contributes to the deformity only in so far as it facilitates medial tilting of the condylar fragments. Cubitus valgus appears less frequently and is due to inadequate reduction of the lateral tilting fragments. The lateral displacement of the distal fragments occurs in approximately 15% of displaced fractures. **Key Words:** Medial tilting, cubitus varus, anatomic reduction, percutaneous pinning.

INTRODUCTION

Displaced supracondylar fractures present a formidable challenge in treatment by any practicing physician. Many of these, however, can be treated by closed reduction and immobilization. This review evaluates supracondylar fractures of the humerus in children which were not easily reduced, or presented complications such as marked swelling, instability, or neurological deficit. These circumstances required a surgical reduction and some form of immobilization.

Often, displaced fractures are stable after reduction and may be managed by closed method such as collar and cuff, or another form of immobilization. Many fractures, however, are unstable after reduction except in the acutely flexed position. If considerable swelling is present, this acutely flexed position may compromise circulation and predispose to a Volkmann's ischemic contracture. Immobilization in the safer right angle position will frequently allow the fragment to slip, thus producing the varus deformity. This has been called "supracondylar dilemma", as described by McLaughlin.

The most popular method of treating the severely displaced unstable supracondylar fracture has been described by Dunlap. Since that time, many modifications of Dunlap's traction have been used, with skeletal traction through the olecranon pulling horizontally and vertically. Traction methods require approximately 3 weeks of hospitalization. Such treatment in traction frequently results in significant loss of carrying angle.

Treatment by open reduction and internal fixation is not popular because

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the method too frequently results in limitation of motion. Additionally, open reduction exposes the patient with a closed fracture to the danger of post-operative infection. Over a period of 6 years, from 1975 to 1980 inclusive, we treated approximately 168 fractures of the distal part of the humerus in children. Of these, 126 were supracondylar fractures. Of the 126 supracondylar fractures, 42 were treated with surgical intervention. Surgical treatment included blind pinning, and open reduction and internal fixation, utilizing Steinmann pins. 28 fractures were treated by blind pinning. 14 fractures underwent open reduction with internal fixation. Patient selection for operative treatment was determined by: 1) the amount of displacement of the fracture, 2) the stability which was present when the fracture was reduced, 3) the position in which the elbow had to be placed in order to maintain reduction, and 4) whether or not adequate circulation and/or neurologic function was present. The majority of our severely displaced fractures, and all of those with marked swelling were treated by one of these two methods.

Of the 42 patients treated, 25 were boys and 17 were girls. There were 28 fractures of the right humerus and 14 fractures of the left humerus. The age range was 2 years to 14 years with the mean being 6.5 years. The period of hospitalization for the 42 patients averaged 2.6 days. All patients who underwent reduction of the fracture and immobilization by insertion of Steinmann's pins first received evaluation of neurovascular integrity and the soft tissue of the elbow.

OPERATIVE TECHNIQUE

All reductions were performed under general anesthesia. The extremity was prepped and draped in the usual sterile fashion. After completing the manual manipulation of the condylar fragments, the forearm was then pronated and the elbow acutely flexed and held in position. Pronation de-rotates the distal fragment from it's frequently medially rotated position, and locks it in corrected alignment. Roetgenograms were then made of the elbow as it was held in position to see if satisfactory reduction and stabilization was achieved. If reduction was satisfactory, it was then pinned. The placement of the pins was similar to those described by Swenson and others. All pinnings were done utilizing a mini-power driver and small smooth Steinmann pins. We used both the medial and lateral approach for pinning. We did not make a stab wound in the skin utilizing a scapel, instead the pin was stabbed through the skin.

When placing the lateral pin, care must be made to engage the pin against the lateral epicondyle. The pin is then directed upward and medially at an angle of approximately 40° to the saggital plane of the humerus and 10° posteriorly to the coronal plane of the humerus. This pin thus passes through the distal fragment and the medullary cavity of the proximal fragment to engage the cortex of the proximal fragment. The medial pin is inserted through the center of the medial epicondyle in a similar manner. Care must be made to avoid the ulnar nerve within the ulnar groove. When swelling obliterates the ulnar groove, gentle pressure with the fingers over the area will massage the edema away and the ulnar nerve will become palpable. Practice is necessary to acquire the skill needed to place the pin through the flat supracondylar region of the humerus. It is imperative that the pin be placed in the exact position, and that trauma does not occur during this placement. The closer the anatomic reduction, the easier the pinning is obtained.

Two of the surgeons included in this study used threaded Steinmann pins. They believed better fixation of the fragments was provided, which helped prevent migration of the pins. We found that smooth Steinmann pins can be used, especially on the ulnar side, to minimize the possible trauma to the ulnar nerve caused by twisting the adjacent tissue. Over the past two years, pinning techniques have been employed under direct C-arm control.

The pins were cut off subcutaneously and a well-padded posterior mold was applied. After adequate fixation of the fraction, the elbow can be held in almost any position without losing reduction postoperatively. The patients were hospitalized between 12 hours and 3 days, and then discharged. We did not remove the pins until the 6th week in most cases, and never earlier than 3 weeks. The pins were usually removed as an office procedure, then active range of motion exercises was started. There was no loss of position or non-union in the study utilizing the two methods as described.

When open reduction with internal fixation was necessary, the majority of these cases were opened from a straight posterior approach, over the distal portion of the insertion of the triceps musculature. The placement of the pins was basically as that noted on the blind pinning technique, however, open reduction had been accomplished. All follow-up examination were performed personally. The criteria for satisfactory end results were cosmesis and functional stability of the elbow. It is important to remember that the patient can have deformity with good function or no deformity with poor function. Of the 42 operative supracondylar fractures, 26 returned for personal evaluation.

In reviewing our criteria for grading results, range of motion was determined with a goniometer. We measured the carrying angle and compared it to that of the normal opposite extremity of each individual. If a reversal of the carrying angle was present, this was graded as a poor result. An excellent result was considered a carrying angle loss between 0° and 5° with a functional motion loss between 0° and 5°. A good result was considered present when the cosmetic carrying angle loss was between 5° and 10° with the functional motion loss between 5° and 10°. A fair result was graded at 10° to 15° loss of cosmetic carrying angle with 10° to 15° functional motion loss. Unsatisfactory or poor results occurred when the cosmetic carrying angle was over 15°, or when the functional motion loss was over 15°. (See figure 1)

Figure 1

Excellent Carrying Angle Loss—0° - 5° Functional Motion Loss—0° - 5°
Good Carrying Angle Loss—0° - 10° Functional Motion Loss—5° - 10°
Fair Carrying Angle Loss—10° - 15° Functional Motion Loss—10° - 15°
Unsatisfactory Carrying Angle Loss—15° or more Functional Motion Loss—15° or more

RESULTS

The results of our 26 patients included the following age breakdown: 6 to 16 months — 1 patient; 1 to 4 years — 3 patients; 4 to 8 years — 6 patients; 8 to 12 years — 10 patients; 12 to 16 years — 6 patients. (See figure 2)

Figure 2

Age Distribution

Age	#Patients
1. 6-26 Months	1
2. 1-4 Years	3
3. 4-8 Years	6
4. 8-12 Years	10
5. 12-16 Years	6
Total	26

The average length of follow-up postoperatively included the following: 6 to 8 months — 2 patients; 8 to 12 months — 10 patients; 1 to 2 years — 4 patients; 2 to 4 years — 6 patients; 4 to 6 years — 4 patients. Of the 4 patients reviewed after 4 to 6 years, 3 were rated as excellent and 1 was rated as excellent and 1 was rated as good. Of the 6 patients who were seen after 2 to 4 years, 4 were excellent, 1 was good and 1 was fair. Of the 4 patients seen after 1 to 2 years, 3 were excellent and 1 was good. The 10 patients seen after 8 to 12 months resulted in 8 graded as excellent, 1 as good and 1 was rated poor. Of the 2 patients seen after 6 to 8 months, both were rated as good. (See figure 3) The 1 poor result was felt

to have occurred because of poor reduction and inadequate stabilization. The surgical procedure was that utilizing the blind pinning technique. The one fair result had a loss of carrying angle of 10° with a satisfactory and normal range of motion. None of the cases showed any type of growth disturbance secondary to the Steinmann pins.

Vascular complications were those that included radial pulse absence at the time of *initial* evaluation. The radial pulse usually spontaneously returned with slight extension of the elbow. Adequate circulation was noted in all patients. All patients retained a radial pulse after surgical repair. We found in 3 patients, after reduction and pinning, that the radial pulse was observed to disappear when the elbow was passively flexed above 90°. The pulse reappeared when the elbow was extended to below 90°. We did not include these in the vascular complications.

Figure 3

Length Follow-Up					
Time	#Patients	Excellent	Good	Fair	Poor
1. 6-8 Months	2		2		
2. 8-12 Months	10	8	1		1
3. 1-2 Years	4	3	1		
4. 2-4 Years	6	4	1	1	
5. 4-6 Years	4	3	1		

We agree with McGlellan and Jones that cubitus varus or valgus deformity which increases after a fracture is reduced is usually caused by poor reduction. The deformity is usually unmasked as extension of the elbow is regained. In most of our follow-up evaluations, it was noted that recovery to basic sound range of motion, was obtained at approximately 1 year.

Medial tilt of the distal fragment is the inevitable sequal of medial rotation and will result in a varus deformity. The few significant changes in carrying angle encountered in our series probably occurred as the result of the tilt of the distal fragment during reduction.

Neurovascular complications are common in supracondylar fractures because of the vulnerable position in which they lie about the elbow. In reviewing the literature, approximately 22% of supracondylar fractures result in some type of neurovascular compromise. Our complication rate was approximately 8% in those operated. Complications were graded by information obtained from the chart records. None of the complications resulted in impairment except 1 elbow which retained approximately 15° loss of full extension.

Neurologic compromise was noted in 6 patients, involving the median nerve. All neuropathys were transitory without recorded permanent sensory loss. No sign of myositis ossificans postoperatively was noted during the period of time these patients were followed and evaluated.

The advantages of surgical treatment include the following:

1) Short hospitalization.
2) Effectiveness in obtaining good results.
3) Avoidance of vascular complications.
4) Ipsilateral fractures can be managed more easily when present.
5) The physician has more latitude in deciding on position of immobilization.
6) Usually a quick procedure with satisfactory results.
7) Less chance of displacement of the fragments post-reduction.

Disadvantages include:

1) Meticulous surgical dissection

when open reduction is accomplished.
2) Technical proficiency required when blind pinning or subcutaneous pinning is attempted. (It is imperative that proficiency be present so that repositioning of the pins is not necessary as this may further traumatize the physeal plate).
3) The risk of pinning the ulnar nerve if the surgeon is not careful to palpate the ulnar groove prior to pinning.
4) Postoperative infection.
5) Muscle or brachial artery present in the fracture site.

X-RAY INTERPRETATIONS

X-ray interpretations of children's elbows are quite difficult because of the multiple ossification centers of the humerus, radius and ulna. The ossification centers number 6. The ossification centers about the elbow appear in X-rays between 18 months and 12 years of age. The distal portion of the humerus is usually ossified from 4 separate centers. The sequence of the radiographic appearance of the ossification centers about the elbow is as follows:

1) capitellum.
2) radial head.
3) medial epicondyle.
4) trochlea.
5) lateral epicondyle. (See figure 4)

Figure 4

Site	Age of Appearance	Age Epiphysis Unites
Capitellum	18 Months	14 years
Radial Head	5 Years	16 years
Medial Epicondyle	5 Years	15 years
Trochlea	10 Years	14 years
Lateral Epicondyle	12 Years	16 years

When evaluating any particular portion of the body radiographically, an AP and lateral film are required. For the elbow, it is quite useful to take exposures of the opposite elbow in the same position for comparison.

Lateral condylar fracture of the humerus represents the most common peri-elbow fracture in children. It is usually found between the ages of 6 and 10 years because the capitellum is not yet fused to the trochlea. Above the age of 10, this type of fracture is unusual because the capitellum and trochlea have fused and therefore keep the fracture from occurring. The mechanism of injury is usually a varus stress on an extended forearm due to a fall on an outstretched hand. The muscle attachment of the common extensors of the wrist and fingers act to displace the fragment distally as well as rotating it. The rotational orientation of the fracture will provide a clue to the degree of displacement. There may be an associated methaphyseal fragment which is called a Thurston Holland's sign.

In minimally displaced fractures of the lateral epicondyle, simple splinting with a posterior mold can be utilized. If there is displacement of the lateral humeral condyle, it requires open reduction and internal fixation with anatomical alignment, since with this, there is potential for further displacement. Steinmann pins or K wires are placed in parallel fashion to provide stability. Multiple attempts at closed reduction should be avoided because of the unlikelihood of obtaining a stable reduction.

Complications evolve from not recognizing displacement and/or rotation of the fracture fragment on the radiographs. As a result of this, non-union may occur. Additionally, ulnar neuritis and tardy ulnar palsy are quite common if there has been tethering of the ulnar nerve.

Treatment consists of closed reduction and plaster splint immobilization: If there is marked displacement of the medial epicondyle, it's associated muscle bundle adds to the instability. Con-

sequently, open reduction with internal fixation is required. Complications of the medial eipcondylar fractures are uncommon, but occasionally the ulnar nerve may be injured at the fracture site resulting from a direct blow to the medial elbow. Slight deformity at the site of the displaced fracture may require excision of the fracture fragment at a later date.

ASSOCIATED INJURIES

There were 5 nerve palsies in the entire group of 26 patients. These all recovered spontaneously. There were no ulnar nerve lesion noted, but all cases resulted in radial nerve injuries. There was 1 open fracture with a vascular injury, and 1 patient had an ipsilateral fracture of the forearm with a resultant Clostridium Perfringens infection which was treated effectively.

The development of cubitus varus is related to 2 factors. These are the child's normal carrying angle and the degree of change subsequent to the injury. In our study, an elbow was judged to have a gunstock deformity if sufficient deformity of the distal end of the humerus was present to be clinically noticeable by either the patient or the examiner. No measurements were taken to quantitatively determine this. Gunstock deformities are present in approximately 1.3% of patients postoperatively.

CONCLUSION

It was once thought that medial displacement and internal rotation were responsible for the high incidence of cubitus varus following supracondylar fractures. This has been shared by many authors. Recent studies show the important factor is the medial or lateral tilt of the distal fragment.

The hospitalization time and cost is greatly reduced with a small amount of rotation, but showed no change in the carrying angle. This further substantiates the theory, that change in the carrying angle was due to tilt and not due to rotation. If only one pin is used, this provides insufficient fixation and may lead to an increase in rotational displacement which may require additional reduction. It is advisable and recommended to use a cross-pinning technique so that rotation can be avoided. Percutaneous or open reduction and internal fixation with pinning eases the management of ipsilateral fractures if they are present.

MacClennan, in 1937, unequivocally expressed his opinion that "treatment of fractures of the lower humerus by flexion of the elbow, risks a Volkmann's contracture. In children, most fractures about the elbow joint with displacement require an open reduction. The end results following open reduction are far better than those obtained by closed management". His observations and many authors since then conclude that open reduction and insertion of cross wires across the physeal plate, with or without subsequent removal, was not followed by any type of growth disturbance. Cubitus varus and cubitus valgus deformities complicating closed treatment were, in most instances, due to an imperfect reduction, becoming "unmasked" as the elbow joint extension was regained.

Sandegard in 1943, and Holnberg in 1945, following extensive studies of the lower humeral fracture, concluded that surgical intervention and internal fixation produced results comparable with or superior to closed methods.

There is certainly much controversy as to the use of conservative care with traction and immobilization as opposed to open reduction and possible blind pinning. Change of established methods, even unsatisfactory methods, do not come about easily. As recently as 1963, in an often quoted text on fractures in children, the following statement was made: "blind pinning with protruding pins is always undesirable in children".

Percutaneous pin fixation, in our experience, has been demonstrated to be a most satisfactory method of assuring and maintaining reduction following a fracture of the lower end of the humerus in children. It has been frought with few complications and the

end result has been most gratifying from both the aspects of cosmesis and function. It helps to assure the maintenance of reduction without compromise to circulation or precipitating growth disturbances in children.

ILLUSTRATIVE CASES

Figure 1A

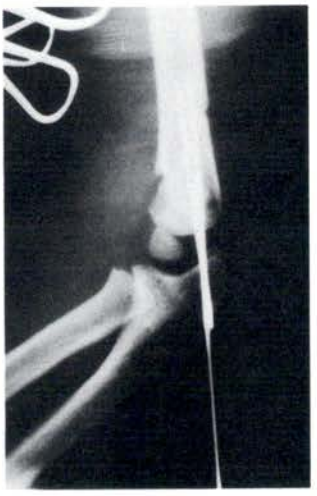

Figure 1B

Figure 1C

E.P. is an 8 year old female who fell from a swing set with a resultant transcondylar fracture of the left distal humerus.

Closed reduction was accomplished under general anesthesia. Percutaneous technique was completed with Steinmann pins. She was immobilized for 3 weeks with a posterior mold. Final results, both radiographically and clinically, were satisfactory. (See 1A, 1B, 1C)

Figure 2A

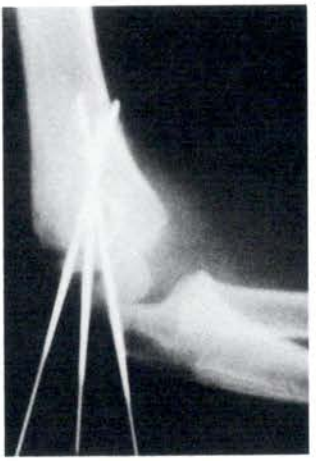

Figure 2B

Figure 2C

J.R. is a 12 year old male who sustained a fracture of the distal left humerus secondary to an automobile accident.

Because his neurovascular function was compromised, open reduction with internal fixation was completed. He was immobilized for 4 weeks. His postoperative course was uneventful and he maintained full range of motion without sensory deficit. Growth and development to date have remained intact. (See 2A, 2B, 2C)

Figure 3A

Figure 3B

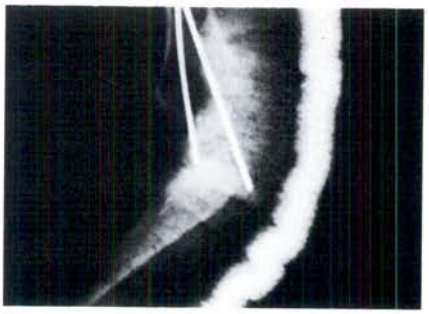

Figure 3C

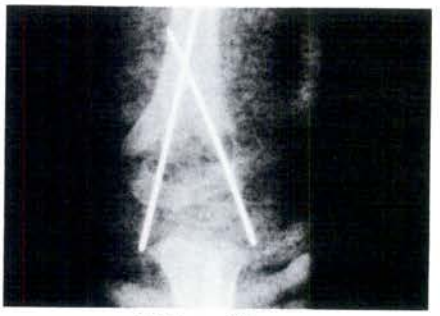

Figure 3D

S.S. is a 7 year old male who was injured secondary to a bicycle accident. He had a transient radial nerve defect at the time of initial evaluation. Open reduction with internal fixation was completed. Cross pin technique was utilized for stabilization.

This patient's postoperative course was satisfactory. He had a functional loss of pronation of 10°. He has not had a change in physeal development since the time of injury. (See 3A, 3B, 3C, 3D)

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A Cause for Chronic Shoulder Pain: Suprascapular Nerve Entrapment

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Abstract: Disabling shoulder pain can tax even the best diagnostician. Arriving at an accurate diagnosis can be both frustrating and time-consuming, resulting in patient dissatisfaction and protracted disability. The physician, eager to relieve the pain, may resort to symptomatic treatment without definition of the pain's origin. It is vital that a thorough history of the pain pattern be used in the selection of diagnostic measures which will uncover the problem.

In the case of nonlocalized shoulder pain which is aggravated by movement and cannot be ascribed to a skeletal injury/lesion or inflammatory reactions, motor neuropathies should be investigated. One of the least common of these is suprascapular nerve entrapment. Compression of the suprascapular nerve manifests itself in a shoulder nonmechanically frozen by a dull pain which is made worse with motion, particularly forced adduction. Suprascapular nerve block is both therapeutic and diagnostic for this syndrome. Treatment may be conservative, but surgery to decompress the nerve is recommended for permanent pain relief. **Key Words:** suprascapular nerve, entrapment neuropathy, chronic shoulder pain, surgical nerve decompression.

INTRODUCTION

Chronic, disabling shoulder pain often poses a perplexing diagnostic dilemma for the physician, particularly when the physical findings are inconsistent with the more common causes, such as arthritis, bursitis, and tendonitis. For the sake of expediency, the practitioner may fall prey to the temptation to "experiment" with remedies in hopes that the solution will be found without actually knowing the origin of the pain. However, results of such symptomatic treatment are usually only temporarily successful; in the end, the pain persists and the patient's disability has been prolonged. To avoid this, the physician must take the time to investigate the situation, eliciting a thorough history of the patient's activities prior to the pain and defining the pain pattern precisely. Armed with this preliminary data, it is then possible to judiciously select appropriate diagnostic measures to ascertain the etiology of the pain.

In this paper, we would like to present one of the more rare neurologic causes of shoulder pain, suprascapular nerve entrapment, outlining its origin, identification, and treatment for the benefit of the physician who is confronted with a chronic, disabling shoulder pain syndrome. Two case reports exemplify the problems associated with the diagnosis of this neuropathy.

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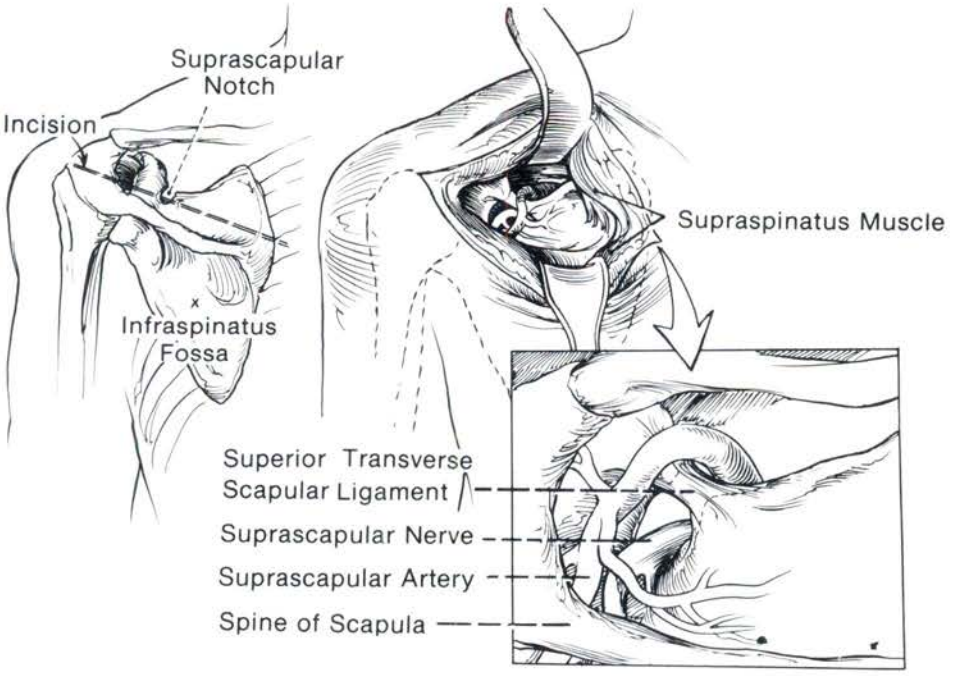
ANATOMY AND CLINICAL IMPRESSIONS

The suprascapular nerve, arising from the upper trunk of the brachial plexus, is a motor nerve which courses laterally deep in the trapezius and omohyoid muscles, entering the supraspinous fossa via the suprascapular notch. At this point, the nerve lies in a foramen composed of the suprascapular notch and the overlying trans-

verse scapular ligament (Figure 1). The nerve then divides to provide motor branches to the supraspinatus and infraspinatus muscles with sensory branches extending to the acromioclavicular and glenohumeral joints and the conoid, coracoacromial, and trapezoid ligaments.



Entrapment of the suprascapular nerve usually results from continuous or traumatic extreme adduction of the arm across the chest.[1,2] This motion stretches the nerve, leaving it vulnerable to damage by the bony edges of the suprascapular notch. The nerve's inflammatory reaction to this interaction with the bone leads to compression by the transverse scapular ligament. Suprascapular nerve entrapment has also been reported to occur with scapular fractures,[3-5] wrist injuries,[6] and humeral or acromioclavicular joint trauma which inflames the nerve.[7-9]

The inflamed, compressed suprascapular nerve produces an immediate, deep, continuous, dull ache. The nonlocalized pain is not relieved by rest and is aggravated by shoulder motion, particularly by forced adduction. However, this restriction is secondary to pain and not mechanical. The pain pattern may involve radiation to the neck or forearm, probably due to the nerve's fixation in the foramen, causing traction on its upper trunk origin. Weakness on external rotation and/or abduction may also be witnessed. If the neuropathy is chronic, wasting of the spinatus muscles is frequently observed with disuse atrophy of the deltoid muscle a late finding.

Radiologic examination of the cervical spine and shoulder joint are generally negative, as are myelography and sensory examinations. Electromyographic studies may reveal denervation of the spinatus muscles, although this is not considered confirmatory by some physicians.[4] Suprascapular nerve block by hydrocortisone/xylocaine injection into the suprascapular notch is frequently both diagnostic and therapeutic.[4,6,9]

TREATMENT

Selecting the appropriate therapeutic modality, either conservative or surgical, rests largely with the severity of the compression and inflammation. Treatment may be as simple as removal of the offending activity in cases of non-

traumatic evolution. Shoulder immobilization, nerve block, diathermy, ultrasound, and range of motion exercises may also be of some benefit, although most authors have found these measures to offer transitory improvement only.[1,3-6] If disability and muscle wasting are advanced or the pain persists after conservative therapy, surgical correction is indicated.[1,3-8]

Surgical treatment of suprascapular nerve entrapment consists of either lysis from the superior transverse ligament, resection of the suprascapular notch, or both.[1,3-8] The point of nerve compression may be approached posteriorly, with an incision parallel to and above the scapular spine, dividing and elevating the trapezius muscle.[3] An anterior approach, though, is perhaps preferential, inasmuch as it spares the trapezius muscle and provides better visualization of the neurovascular structures.[5,8] Widening of the foramen with a laminectomy rongeur does release the nerve from its bony tether, but the technique may leave irregular surfaces which might further irritate the nerve. This resection procedure is also somewhat more hazardous to the nerve and the suprascapular artery, which lies in close proximity. Both techniques, however, produce immediate, permanent relief of symptoms.

CASE REPORTS

1. A 58-year-old male experienced severe pain in the right shoulder and neck in a work-related accident. Over a four-month period, conservative outpatient therapy failed to relieve this pain. Myelography was performed five months after initial injury, revealing an extradural defect at C_{5-6} and C_{6-7} on the right and left. Cervical fusion was performed with minimal improvement. Conservative measures, including injections, neck traction, oral analgesics, and diathermy, were successful. Seven months later, the shoulder pain, now more localized to the superior border of the right scapula, was re-evaluated. Pain continued to radiate into the cervical area and right arm. An electromyogram demonstrated no denervation of the spinatus muscles at this time, and a suprascapular nerve block was performed with resolution of the pain. One month following this diagnostic procedure, the patient underwent right suprascapular nerve decompression. He continues to be symptom-free two years postoperatively.

2. A 37-year-old mechanic sustained a traction-type injury to his right shoulder at work. Constant pain produced shoulder immobility and he was unable to work. Initial therapy with hot packs, ultrasound, and "trigger point" cortisone/xylocaine injections failed to alleviate the pain. Over the next four months, the patient consulted two different orthopedic surgeons and a neurologist. Electromyographic studies, a cervical myelogram, sensory examination, range of motion tests, and tendon reflexes were all normal. He had extensive conservative care, hospitalization with traction, and immobilization of the right upper extremity; all these measures were ineffective. Finally, five months after injury, right suprascapular nerve block was performed with complete relief of pain. Surgical decompression of the right suprascapular nerve provided permanent relief of symptoms.

DISCUSSION

Chronic, immobilizing shoulder pain is a troublesome diagnostic problem. As the cases discussed here demonstrate, delays of months or even a year may be encountered before an accurate diagnosis is obtained. This is due not only to the elusive or obscure nature of some neuropathies, but may also be compounded by the physician's eagerness to provide relief of pain through stopgap measures. In the end, though, this symptomatic treatment merely protracts the disability and leads to patient disillusionment. It is imperative that the physician obtain a thorough history of the pain pattern and then proceed to select appropriate diagnostic procedures.

The more usual causes of immobilizing shoulder pain, such as rotator cuff

sprain/strain, shoulder dislocation, acromioclavicular separation, polyradiculitis, acute arthritis, and rotator cuff tendonitis or bursitis, can be assessed by physical and radiologic examination. Sensory examinations, reflex studies, and range of motion tests can further help to define the functional disability and the nature of the immobility.

If joint injury, inflammation, and lesions have been ruled out, the neurologic origin of the dysfunction should be considered. Myelograms and electromyographic studies may or may not be of assistance in localizing the neuropathy; however, motor neuropathies are notoriously difficult to diagnose, if preliminary examinations are inconclusive, and the shoulder pain is aggravated by movement, entrapment neuropathies should be suspected before the neurologic dysfunction is ascribed to a more central origin.

From the paucity of cases reported in the literature, suprascapular nerve entrapment appears "rare," but it is most likely more commonplace than thought. Inasmuch as the diagnosis of this syndrome is reached only through a long series of "negative" test results for other more common causes of the non-mechanically frozen shoulder, it is quite likely overlooked on many occasions. Clues to this entrapment neuropathy can be obtained from the increased pain with motion, particularly adduction, and electromyograms which show denervation of the muscles driven by the suprascapular nerve. However, a successful suprascapular nerve block is the most definitive diagnostic indicator.

Although temporary relief of pain and restoration or shoulder mobility is obtained with nerve block, a permanent solution to the entrapment is the treatment goal. This may be done with conservative therapy, but it is more likely that surgery will be required to release the nerve. Whether decompression of the nerve should be achieved by simple lysis of the superior transverse ligament or via resection of the suprascapular notch is not known. Both procedures have been reported as successful,[1,3-8] and it would seem prudent to select the least dangerous and traumatic technique which will accomplish the goal. However, the surgeon should undertake the procedure which he feels confident will relieve the symptoms based upon the visual examination of the condition of the suprascapular nerve and notch.

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The Diagnostic and Therapeutic Approach to Combined Anterolateral and Anteromedial Rotary Instability of the Knee

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ABSTRACT: The common denominator for combined anterolateral/anteromedial rotary instability of the knee is the absence or attenuation of the anterior cruciate ligament. (Table 1).[7] The anterior cruciate ligament plays a major role in preventing anterior movement of the tibia relative to the femur, especially in the terminal 15 to 20 degrees of extension and in preventing abnormal rotation and hyperextension of the knee.[24,26,34] **Key Words:** rotary instability,, anterior cruciate ligament, progressive deterioration.

INTRODUCTION

Chronic instability resulting from anterior cruciate ligament insufficiency leads to progressive deterioration of the knee in experimental animals.[44,53] The goal of the surgeon managing this injury should be to not only prevent the long-term detrimental degenerative changes in the knee, but also to allow the aggressive athlete to function competitively.

It is generally agreed that, when it is feasible, primary repair of the third degree anterior cruciate ligament injury should be performed.[19,41,51,55] It is important to realize that repair of the anterior cruciate ligament alone has been unsuccessful.[20,21,60] Furthermore, early reports combining dynamic backup or augmentation to primary repair or reconstruction of the anterior cruciate ligament are encouraging.[41,60] Adding additional significance, is the frequency of the anterior cruciate ligament injury being more common than has been appreciated in the past in the typical knee sprain with traumatic hemarthrosis.[19,37,47]

This paper presents a diagnostic and therapeutic approach to combined anterolateral and anteromedial instability of the knee, secondary to anterior cruciate ligament insufficiency.

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MATERIALS

Nine patients are presented. There were seven males and two females, their ages ranging from 17 to 35 years, with an average age of 21. The length of time that the patients presented with anterior cruciate ligament insufficiency varied from one day to two years. Two patients had undergone previous surgical procedures. All of the patients had absence or attenuation of the anterior cruciate ligament. Six were chronic anterolateral/anteromedial instabilities and three were acute third degree tears of the anterior cruciate ligament, which were determined at

TABLE I

Anteromedial	Anterior	Anterolateral
Medial capsular	Medial capsular	Lateral capsular
Tibial collateral	Lateral collateral	Arcuate complex
Post. oblique		
Anterior cruciate	Anterior cruciate	Anterior cruciate

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surgery to be non-reparable primarily. All patients had a lateral pivot shift (anterolateral rotary instability approaching extension), as well as an anterior drawer (straight one plane anterior instability) and a positive Slocum (anterior medial rotary instability) demonstrated preoperatively or at examination under anesthesia. None of the patients had a posterior or lateral one plane instability. None of the patients had a posterolateral or a posteromedial rotary instability. One patient had a 2+ one plane medial instability secondary to a second degree and partial third medial collateral ligament injury. The patients presenting with chronic instability were selected for surgery because of their failure to respond to an adequate rehabilitation regime. The acute patients were selected for surgery because of the nature of the anterior cruciate ligament injury preventing satisfactory re-attachment and primary repair. The longest follow-up is 12 months, the shortest follow-up is eight weeks.

CASE REPORT

A 20 year old white male presented as an out-patient complaining of his left knee giving-way when attempting cutting manuevers playing racquet sports. He gave a history while playing college football of attempting to receive a pass, making a cut toward the mid-field with his foot planted. He felt a pop, a giving-way sensation in the left knee and then had a knee effusion which developed within 12 hours. He was seen by a physician who made the diagnosis of "knee sprain" and prescribed treatment. Following this, the patient states that his knee gives-way with cutting manuevers periodically and he is unable to perform athletic endeavors. He was placed in an aggressive rehabilitation program, but did not respond. He was admitted to the hospital for arthroscopy after an examination revealed a 3+ anterior drawer, a 3+ lateral pivot shift and a 3+ positive Slocum. Arthroscopy confirmed a remnant of the anterior cruciate ligament as well as a tear in the posterior horn of the medial meniscus. The surgery performed was intra-articular patellar tendon substitution for the anterior cruciate ligament, as well as iliotibial band transfer and pes plasty. The patient recovered satisfactorily from surgery. He was placed in a long leg cast following surgery for four weeks and then into a hinged light cast for ten weeks. The hinged cast was replaced with a Lenox-Hill brace when he could perform quadresistive exercises against 25 pounds. He is continuing in his rehabilitation program, and examination at the time of removal of the hinged cast revealed a negative lateral pivot shift, a negative Slocum and a 1+ anterior drawer.

METHODS

The patients with chronic instability were rehabilitation failures. The operative procedure was preceded by arthrogram and arthroscopy. The patients with acute injuries were all arthroscoped and/or arthrogrammed. An examination under anesthesia was performed to determine the type and degree of instability. A diagnosis of anterior cruciate ligament was confirmed in all cases by arthroscopy. The surgical procedure was always preceded by a thorough discussion between the surgeon and the patient. The purpose of this discussion is important, for the relative merits of surgical versus non-surgical treatment for the third degree anterior cruciate ligament injury, either acute or chronic, must be thoroughly presented.

OPERATIVE TECHNIQUE AND POST-OP MANAGEMENT[10,17,18,19,57]

An incision is made approximately six centimeters to the medial edge of the patella. The superior aspect extends six centimeters above the patella and the inferior aspect of the incision to just below the level of the tibial tubercle. The joint is opened through a medial para-patellar incision. The interior of the knee joint is examined and any other necessary surgery performed. The intercondylar notch is debrided. The pes anserinus is mobilized in the manner of Slocum. The soft tissue

covering the patella down to the level of the tibial tubercle is dissected and retracted. The retinaculum covering the patella and the patellar tendon down to the level of the tibial tubercle is sharply incised and retracted. This retinaculum, at the completion of the procedure, will be re-approximated. A knife is used to mark the medial third of the patellar tendon one centimeter wide from above the patella to the level of the tibial tubercle. The most medial edge of the patella is left intact. An oscillating saw is then used to initiate the osseous component to be removed from the patella. An osteotome is used to remove this osseous flap from the patella. This one centimeter wide patellar teno-osseous unit is carried down to the level of the tibial tubercle. The insertion of the patellar tendon into the tibial tubercle is left intact. A 3/8" drill hole is then used to form a tunnel from the level of the tibial tubercle of the medial region of the insection of the anterior cruciate ligament (Fig. 1). It is important not to place this drill

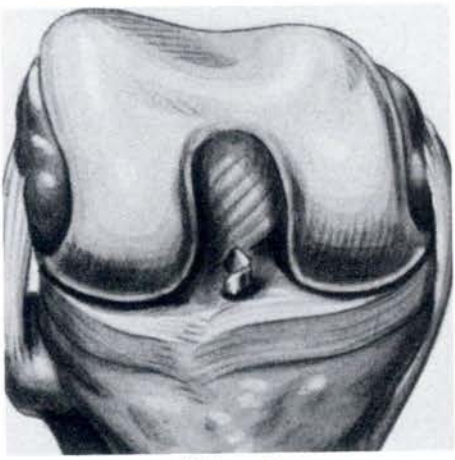


Figure 1
A 3/8" drill is used to form a tunnel in the proximal tibia from the level just above the tibial tubercle to the region of the insertion of the anterior cruciate ligament.

hole laterally. At least four sutures are passed through the transplant and a suture passer is then utilized to pass the transplant through the tibia, bringing the transplant along with the sutures. The transplant is passed through the previously incised fat pad to enable encasement of the patellar tendon by a potential blood supply.

A lateral incision is then made approximately six centimeters lateral to the edge of the patella. The proximal aspect of this incision is approximately six centimeters above the patella and the distal aspect to the level of Gerdy's tubercle on the tibia. An inicision is made through the iliotibial tract approximately 2-1/2 centimeters from its posterior aspect. Ellison's modification is carried out, detaching the iliotibial tract distally with a small wafer of bone from Gerdy's tubercle. The band is approximately 1-1/2 centimeters wide. A tunnel is then created in the posterior lateral femoral condyle (Fig. 2). This is

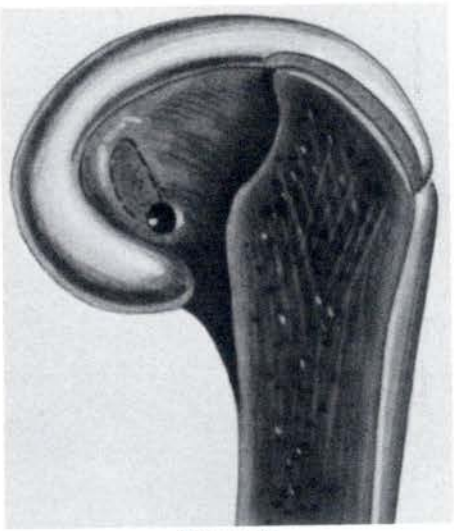


Figure 2
***A:* A tunnel is created to 3/8" in the posterior lateral femoral condyle.**
***B:* A tunnel created in this position would be incorrect and too far anterior.**

done by first placing a 7/64" drill hole deep in the intercondylar notch and then passing it out posterior laterally, so as to approximate the true course of the anterior cruciate ligament as is possible. The tunnel is enlarged until the 3/8" drill hole has been used. The teno-osseous transplant, with its attached sutures, is then brought out through this femoral tunnel using suture passers (Fig. 3). The teno-osseous transplant has never been too short and is often slightly too long, requiring excision of a small portion of the end

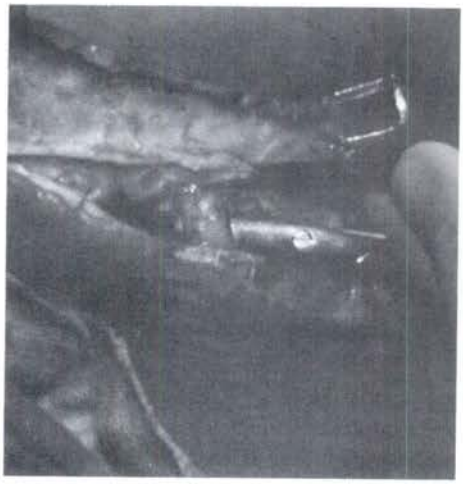
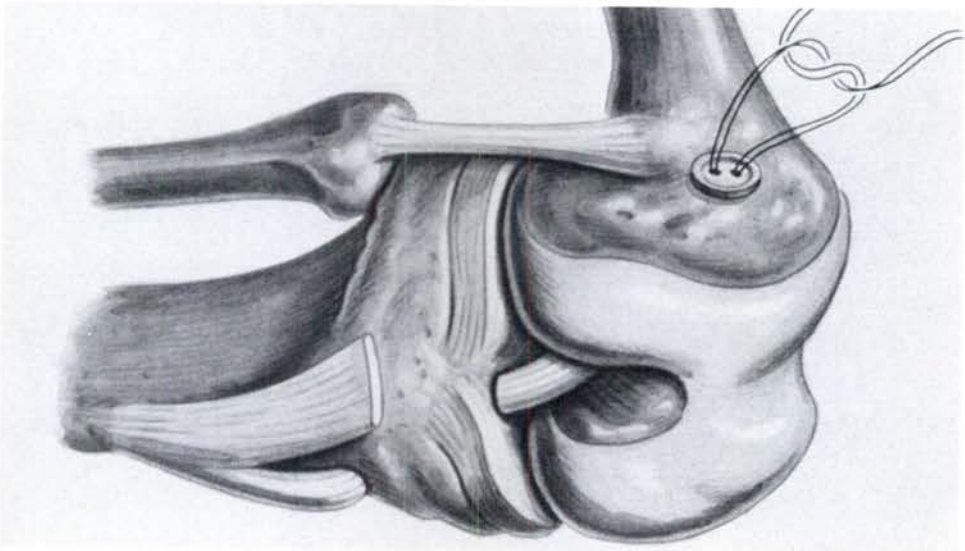
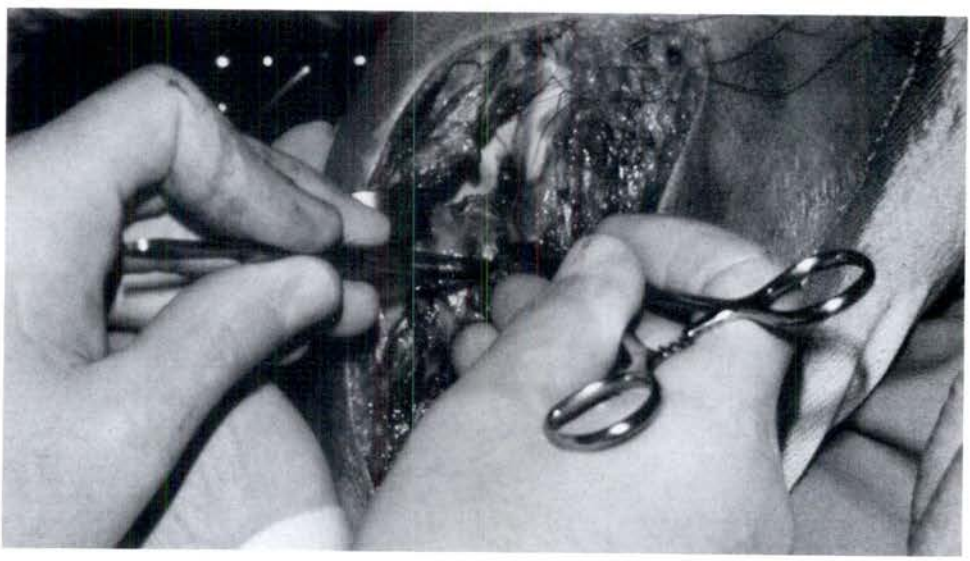


Figure 3
The teno-osseous transplant, with its attached sutures, is shown being brought out through the femoral tunnel using suture passers. Multiple sutures may be utilized.

Figure 4
A method for securing the teno-osseous transplant at the posterior lateral femoral condyle with the sutures individually tied over a polyethylene button, the knee is in approximately 40 degrees of flexion.

Figure 5
A: **Absorbable sutures are utilized to encase the transplant in the fat pad.**
B: **Shows tension being placed laterally in the long axis of the transplant by its attached sutures.**





of it. The knee is then flexed in order to take out all the slack of the transplant and the suture individually tied over a polyethylene button with the knee in approximately 40 degrees of flexion (Fig. 4). The fat pad is then secured around this transplant in the knee joint with absorbable sutures (Fig. 5).

The remainder of the pes anserinus procedure is then completed in the manner of Slocum. The iliotibial tract on the lateral side, which had been mobilized, is then passed beneath the fibular collateral ligament (Fig. 6) and reattached as much as anterior and distal in the region of Gerdy's tubercle as possible. This is fixed with a staple.

Figure 6

***A:* The fibular collateral ligament, behind which, the iliotibial tract is passed.**

Prior to this, if it is necessary, a lateral meniscectomy can be performed through this exposed lateral incision. Following the transfer of the iliotibial tract, the defect in the iliotibial tract is approximated posteriorly and anteriorly over the transplanted portion. Following these procedures, the knee is thoroughly irrigated, drains are placed medially and laterally and routine closure is performed.

With the knee in 40 degrees of flexion, a long leg cast is applied with adequate compressive dressing beneath the cast. At three to four weeks, the long leg cast is replaced with a hinged cast and the hinged cast remains in place for another ten weeks. During this ten week period, full rehabilitation of the hip and lower extremity muscles is initiated. Isometric exercises (straight leg raises, quadriceps setting, lateral leg raises) are performed until 70 degrees of motion is obtained. Isotonic exercises are then begun, starting out with five pounds and progressing in weight achieving ten repetitions with muscle fatigue at the end of each set being achieved. Weights are increased when the patient can easily complete three or four sets. At ten weeks, the patients is removed from the hinged cast and is able to begin walking without support, if an isotonic quadriceps exercise can be performed against 25 pounds resistance. Following removal of the hinged cast, rehabilitation is continued to increase speed, endurance and strenght training. Periodically, muscle function is evaluated by the Cybex machine and activity is dependent upon increases in muscle speed, endurance and strength. Later, functional tests (hopping, figure of eights) are added to the program. Finally, when the operated extremity achieves at least 90 percent of normal muscle function in the extensors and flexors, full participation is allowed on a graduated basis. It should be emphasized that the period of time necessary to develop this muscle function is approximately 12 months.

RESULTS

Seven patients were out of immobilization and their functional status evaluated either by physical examination or by their return to competitive athletics. Two patients were still in casts and their knee stability could not be objectively evaluated. Four patients were rehabilitated sufficiently to return to active competitive sports with no evidence of knee instability. Five patients are in different phases of rehabilitation and when questioned, feel more confidence in their knee than they did preoperatively. One patient

TABLE II

Case No./Age	Interval Between Injury & Surgery	Previous Surgery +	Type of Operation	Complications	PRE-OP: L.P.S.; Slocum; Drawer	POST-OP: L.P.S.; Slocum; Drawer	Return to Athletics
1. 25y/o	2 years	None	*PAT, PTS, ITT, plus medial meniscectomy	None	4+ 4+ 4+	Unknown at this time	Racquet Sports
2. 23y/o	14 months	None	*PAT, PTS, ITT & medial & lateral meniscectomy	None	4+ 4+ 4+	Unknown at this time	Rugby
3. 21y/o	8 months	Medial meniscectomy	*PAT, PTS, ITT & lateral meniscectomy	Required manipulation under anesthesia	4+ 3+ 2+	Unknown at this time	Varsity Soccer
4. 21y/o	12 months	Excision of anterior cruciate ligament remnant	*PAT, PTS, ITT & lateral meniscectomy	None	3+ 3+ 3+	Unknown at this time	Basketball
5. 35y/o	3 weeks	None	*PAT, PTS, ITT,	None	3+ 2+ 1+	0 1+ 1+	In rehabilitation
6. 20y/o	6 months	None	*PAT, PTS, ITT, & medial & lateral meniscectomy	None	3+ 3+ 3+	0 1+ 1+	In rehabilitation
7. 20y/o	2 weeks	None	*PAT, PTS, ITT	None	3+ 3+ 2+	0 1+ 1+	In rehabilitation
8. 17y/o	1 day	None	*PAT, PTS, ITT	None	4+ 4+ 3+	** ** **	In rehabilitation
9. 14y/o	6 days	None	*PAT, PTS, ITT	None	3+ 2+ 2+	** ** **	In rehabilitation

*PAT = Pes Anserinus Transfer; PTS = Patella Tendon Substitution; ITT = Ilio Tibial Transplant

**Currently in hinged cast.

(Case #3) required manipulation under anesthesia and this was considered due to a prolonged period (nine weeks) in a long leg cast post-operatively. He subsequently regained his range of motion and returned to variety soccer without evident of knee instability. All patients had at least one to two grades decrease in the Slocum and drawer tests, none of the patients had a lateral pivot shift post-operatively. (Table II)

DISCUSSION

Eriksson[19] reported the most common reason for acute hemarthrosis in the knee joint was an injury to the anterior cruciate ligament. Noyes, et al.,[47] reported in a prospective study that 77 percent of typical knee sprains with traumatic hemarthrosis had complete or partial injury to the anterior cruciate ligament. Liljedahl and Nordstrand[37] found partial or total rupture of the anterior cruciate ligament in more than 90 percent of all acute knee injuries seen. The significance of the anterior cruciate ligament in dynamic stability of the knee has been the object of many laboratory and clinical studies.[24,26,34]

It is known that there are competitive athletes who function successfully without an anterior cruciate ligament, however, the combined instability that so often occurs in the anterior cruciate ligament insufficiently, is well documented. Indeed, 95 percent of patients undergoing surgical procedure for chronic combined anterior anterolateral/anteromedial rotary instability of the knee have a significant attenuated or absent anterior cruciate ligament. As Allman observed in reference to the natural history of the injury and its functional significance, it is "the beginning of the end".[6]

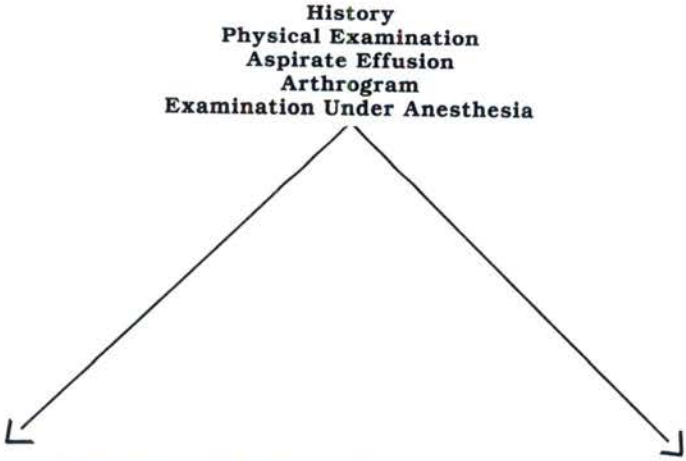
Further support for definitive treatment of this condition is that experimental work with dogs and similar clinical findings in humans have shown that in the anterior cruciate ligament deficient knee there are long-term detrimental effects in the knee joint, including periarticular osteophytes and a high incidence of meniscal tears secondary to anterior cruciate ligament insufficiency.[40,41,42,45,52] Therefore, the diagnosis should be entertained in all acute knee injuries, particularly those that have a maximal hemarthrosis within 12 hours with a history of a pop during a cutting manuever with the foot planted.

It has been our experience, and that of others, that examination under anesthesia is most often required to determine the true extent of the injury and the type and degree of instability. The lateral pivot shift (anterolateral rotary instability approaching extension) has been the most consistent and reliable clinical sign in our hands. This has been a constant finding in the presence of a minimal anterior drawer. The pivot shift,[40] the jerk test,[28,29,30] the anterolateral rotary instability test,[56] and the flexion rotation drawer test[47,48,50] are all variations of a similar clinical manuever describing the anterolateral phenomena.

It is important to follow a protocal in the management of an acute knee hemarthrosis that will yield a precise diagnosis. The protocal established in this series of patients is as follows: history, physical examination, aspirate effusion and arthrogram, examination under anesthesia, and arthroscopy (Table III). The examination under anesthesia and arthroscopy dictate whether a patient is placed in a rehabilitation program or undergoes a surgical procedure.

There are many procedures available to the surgeon managing an acute or chronic combined instability secondary to deficient anterior cruciate ligament. In this regard, it is important to determine the objectives of the procedure. Available to the surgeon are procedures designed to substitute intra-articularly for the anterior cruciate ligament. In addition, there are ancillary procedures which provide a check rain medially and laterally preventing the abnormal anterior and rotatory movement of the tibia. Over 50 years ago, Hey Groves,[27] and later Palmer,[55] transplanted fascia lata intra-articularly to the tibia. O'Donoghue[51,53] modified this procedure noting that the

TABLE III



AMR = Antero-medial Rotary Instability
ALR = Antero-lateral Rotary Instability
COMB = Antero-medial/Antero-lateral rotary Instability

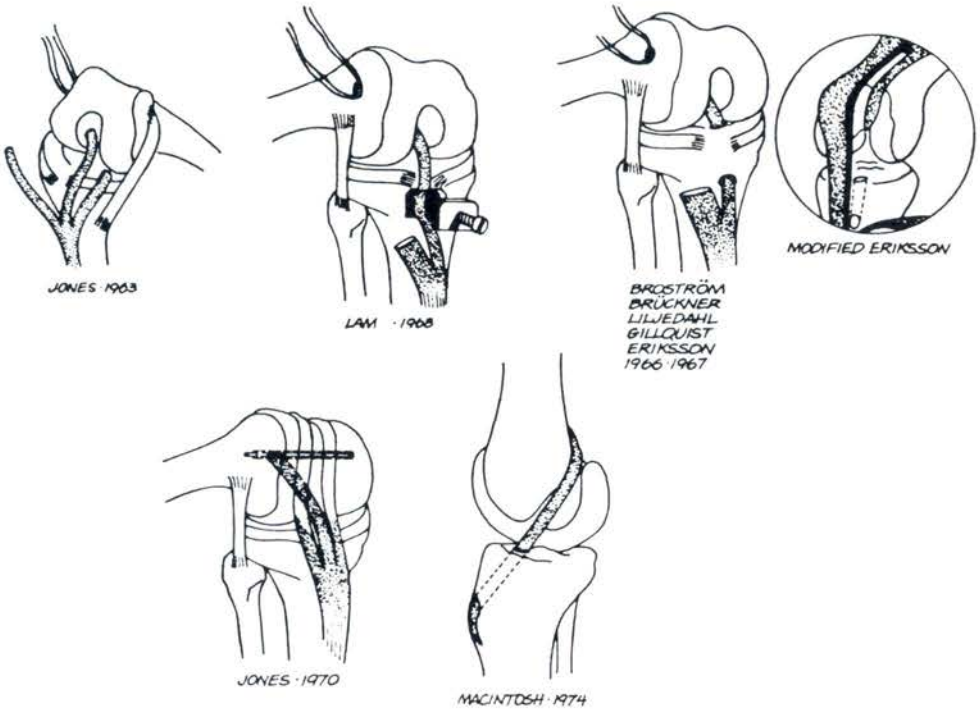


Figure 7

Patellar tendon substitution for the anterior cruciate ligament. Some of the major modifications of the original Jones procedure (1963).

fascia lata transplant, as a substitute for the anterior cruciate ligament, degenerated with time. The semi-tendinosis,[9] the gracilis[16] and the iliotibial tract[31] have also been described as an intra-articular substitution with the goal being to provide some static restraint as well as dynamic stabilization, in that the proximal musculature attachment remains intact.

Prosthetic implants, when subjected to critical analysis, fail with large muscle and joint forces as occurs in the active young person.[50]

There is abundant literature in the use of the "meniscus" as a substitute.[14,38,39,58,59] At present, there is no hard experimental data showing the fate of this meniscus transplant.

In America and Scandinavia, the patellar ligament and/or a teno-osseous unit of the patella and patellar ligament have been studied extensively. Jones[33] reported his results and since that time various modifications of this procedure have been reported.[2,3,5,8,11,12,15,32] These modifications involve the route of the patellar ligament at the tibia, whereas Jones originally described the patellar transplant going over the crest of the tibia. Further modifications route the transplant through a tunnel in the proximal tibia. Additional modifications include the method by which this transplant comes to its ultimate fate in the lateral femoral condyle, or posterior lateral femur; and also, which portion of the patella the osseous component is removed (Fig. 7). Clinical reports and follow-up of this procedure have been favorable.[19,23,25,32,35] Alm[4,5] reported the importance of the placement of the transplant, emphasizing that it be positioned far back in the intercondylar notch and exiting in the lateral femoral condyle far posterior and lateral, in order to duplicate anatomically the normal course of the anterior cruciate ligament. MacIntosh[40] described the over-the-top repair as a solution to this problem. Experimental evidence sup-

porting intercondylar survival of the teno-osseous transplant is favorable.[1,13]

In that the patellar teno-osseous unit is a substitute for the anterior cruciate ligament providing passive support, the use of extra-articular procedures in diminishing anterolateral and anteromedial rotary instability should be considered.

Anteromedial rotary instability and its diagnosis, being one of the first rotary instabilities described, has achieved more understanding than anterolateral rotary instability. When Slocum and Larson[57] initially reported this concept, they stated that, "anteromedial rotary instability is only present with rupture of the medial capsular ligament", and is accentuated with other injuries, especially the anterior cruciate ligament. Therefore, performing a pes anserinus transplantation as a dynamic back-up in an isolated anterior cruciate ligament lesion without medial capsular damage is not without controversy. Indeed, whether an anterior cruciate ligament is ever an isolated injury is a subject of debate.[32,33,34,48,57,60] Noyes and Sonstegard[49] found a doubling effect in rotatory effectiveness at 30 degrees and 60 degrees knee flexion after pes anserinus transplantation. Lesser amounts of rotatory effectiveness were found as the knee goes into extension, however, this terminal 20 degrees as the knee goes into extension appears to be where the anterior cruciate ligament deficient knee is most unstable. Fox, et al.[22] querried patients pre and post surgery in reference to their confidence in the operated knee and its stability. Eighty-seven percent were able to participate in athletics, however, only 62 percent had regained 90 percent of their pre-injury confidence in knee stability. These patients had pes anserinus transplantations for pure anteromedial rotary instability. It has been stated that perhaps the pes anserinus transplantation has been "over-bought"[5]; an alternate method is to advance the semi-membranosis[18] or perform other procedures for anterior medial rotary instability.[46,54]

Completing the check rein on the tibia on the Interal side, one can choose one of the extra-articular iliotibial tract procedures. MacIntosh[40] and Ellison[18] report favorable results if these surgeries are performed to exact technical detail.

The Ellison procedure[17,18] is performed with the knee in flexion and with the tissue of iliotibial tract being fashioned in a straight line to Gerdy's tubercle and securing the transplant with a staple with the tibia posterior under the femoral condyle.

Transfer of the biceps femorus as an ancillary procedure on the lateral side can be accomplished by re-routing the biceps femorus after it has been detached from the head of the fibula, beneath the fibular collateral ligament or as an adjunct to iliotibial tract transplantation by attaching it to the transferred portion of iliotibial tract.[36,43]

SUMMARY

1. The significance and frequency of the third degree anterior cruciate ligament injury has been presented.
2. An aggressive portocol directed toward precise diagnosis is mandatory.
3. Surgical treatment requires thorough knowledge of the technical details involved in the reconstructive procedures.
4. A complete long-range rehabilitation program is equally important as the treatment.
5. The goal of the surgeon is to provide early diagnosis and treatment to prevent the deterioration of the knee joint and allow the competitive athlete to function successfuly.
6. This report is not intended to provide long-term results of functional and objective stability.

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The Lauenstein Procedure: an Alternative Treatment for Distal Radioulnar Joint Disorders

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ABSTRACT: In the following paper the Lauenstein procedure is discussed as a method of treatment for the painful disease of the distal radial ulnar joint and as an alternative to the Darrach procedure. The anatomy of the distal radial ulnar joint is reviewed. The literature is reviewed as well as treatment of distal radial ulnar joint problem. The surgical procedure itself is reviewed in detail. A total of eight patients were treated with the Lauenstein procedure in this paper. One case presentation is presented in detail and a table with all eight patients is included in the article. The results and discussion are also included. The authors feel the Lauenstein procedure does provide stability and properly aligns the distal radial ulnar joint by forming a pseudarthrosis of the distal ulna; therefore, increasing range of motion, especially in supination and pronation in cases which have been markedly restricted. We feel this offers an excellent alternative to the standard Darrach-type procedure for treatment of the distal radial ulnar joint disorders. **Key Words:** Distal radio ulnar, joint degeneration, corpus ulnar drift, arthroplasty.

INTRODUCTION

The dysfunctional distal radioulnar joint may present the orthopedist with a difficult problem. It may result from a variety of causes and disease processes. Vulnerability to injury during a fall may result in a typical Colles — like fracture with resultant osteoarthritic changes or volar or dorsal displacement of the head of the ulna distally. Rheumatoid arthritis may cause pain with degeneration of this joint as well as decreased range of motion, especially supination and pronation. Radial impaction deformity secondary to fracture may lead to a painful distal radioulnar joint. The above problems can cause limited rotation of the forearm, that being supination and pronation as well as decreased flexion and extension at the wrist.

ANATOMY

The stability of the distal radioulnar joint is maintained by many structures: the triangular fibrocartilage or articular disc has its attachment on the margin of the ulnar notch of the distal radius and its apex attached to the base of the styloid process of the ulna;[8] the ulner collateral ligament from the tip of the ulnar styloid to pisiform and triquetrum;[15] the anterior and posterior radioulnar ligaments which are part of the joint capsule;[15] the pronator quadratus muscle;[15] and to a lesser degree, the extensor carpi radialis tendon, the depth of the ulnar notch of the radius and the dorsal carpal ligament.[6]

During supination and pronation the ulna maintains its position while the radius rotates. With the exception of some torque about its axis, the position of the ulna remains unchanged.[6]

Disruption during injury or disease processes may damage or seriously compromise the stability offered by the above structures therefore leading to pain, decreased rotation and deformity.

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REVIEW OF LITERATURE AND TREATMENT

Treatment options of the distal radioulnar dysfunction or disorders are many. They include ligamentous reconstruction such as outlined by Bunnell and Liebolt who developed the soft tissue procedures for restoration of the continuity of the distal radioulnar joint.[3,10] Fascia or tendon grafts were used for these procedures. The results with these procedures however were poor and were technically difficult to perform.

The Darrach procedure first described in the literature in 1912 by William Darrach is as follows: "the lower inch of the ulna was removed subperiosteally, the styloid process, which has been broken off, (due to fracture) being left behind."[4]

Many authors have described good results with the Darrach procedure.[1,4,5] Emphasis was placed on the amount of bone resected and the cosmetic or functional improvement. However, as a result of this procedure, the radiocarpal joint may become very unstable with resultant ulnar migration of the carpus. There is usually an accompanying weakness of grip. There may be a bony over-growth of the ulna if the periosteal sleeve was left intact and there has been an increase incidence of proximal radioulnar joint arthrosis reported along with the ulnar drift of the carpus.[7]

Along with the loss of anatomical relationship of the distal radioulnar joint, another problem with the Darrach procedure has been described by Swanson. The extensor carpi ulnaris tendon assists in stabilization of the wrist as it crosses the dorsal surface of the ulna. In cases of dorsal angulation or resection of the ulnar head, the extensor carpi ulnaris tendon actually becomes a wrist flexor as well as increasing ulnar deviation.[16] Therefore, Swanson uses an intramedullary stemmed implant to cap the distal ulna when resected. Ulnar carpal drift is prevented; length of the ulna is maintained; and by forming a sling from the extensor retinaculum, the position of the extensor carpi ulnaris is maintained.

Milch has pointed to the possible injury to the ulnar collateral ligament and its adverse effects as a "danger" of the Darrach procedure.[12,13]

As a historical reference to the Lauenstein procedure, it is attributed to a German surgeon of the late 1800's. References to Lauenstein from Bick,[2] Steindler[14] and McMurray[11] are the only sources available. No specific article is written by Lauenstein regarding the distal radioulnar joint could be found. The article cited by several authors including Goncalves, is an 1890 article reporting on the technique for medial meniscectomy associated with "joint mice".[7,9]

The Lauenstein procedure in actuality consists of the creation of a pseudoarthrosis in the distal ulna and the fusion of the distal radius and ulna with screw fixation and bone graft.

SURGICAL PROCEDURE

A modified Smith-Peterson approach to the distal ulna utilizing an incision beginning at the base of the ulnar styloid distal, to a point 10 centimeters proximal is made between the flexor carpi ulnaris and the extensor carpi ulnaris tendons. The ulnar is exposed on its dorsal surface subperiosteally. All scarified tissue between the distal radius and ulna is removed if present. Of course, care is taken to avoid the dorsal branch of the ulnar nerve. The adjacent surfaces of the radius and ulna are then roughened using a periostal elevator and bone rongeur.

At a point approximately one to one and a half inches or three centimeters proximal to the base of the ulnar styloid an ostectomy is performed. A section of ulna measuring approximately three-quarters to one inch is removed using the bone rongeour.[14] Drill holes may be made through the ulna at each end of the ostectomy in order to avoid fragmentation.

Following removal of the bone, the distal radioulnar joint is reduced anatomically. The ulnar head is positioned in the ulnar notch of the radius, restoring normal joint alignment as

well as contacting the roughened surface of the radius and ulna.

The bones are then united with a cortical bone screw. The ulna and radius are drilled. The length of the screw is determined via depth gauge and then the screw is placed across the ulna and radius. The tip of the cortical screw must not go more than one thread past the radial cortex to avoid possible injury to the superficial radial nerve and radial artery.

Bone chips from the resected portion of the ulna can then be placed dorsally between the radius and ulna to further enhance the fusion site.

Next, the periosteum at the ostectomy site should be removed and this gap then filled with a fascial tissue to prevent bony bridging of the gap. Filling the gap with muscle such as the extensor carpi or flexor carpi ulnaris may lead to a tenodesis effect to the tendons and should be avoided.[14]

It may be necessary to remove more bone from the distal fragment after reduction of the radioulnar joint as a full three-quarter to one inch gap should remain at the ostectomy site. On the other hand, if too much bone is removed from the proximal portion of the ostectomy, problem with clicking and prominence of this proximal portion may result.

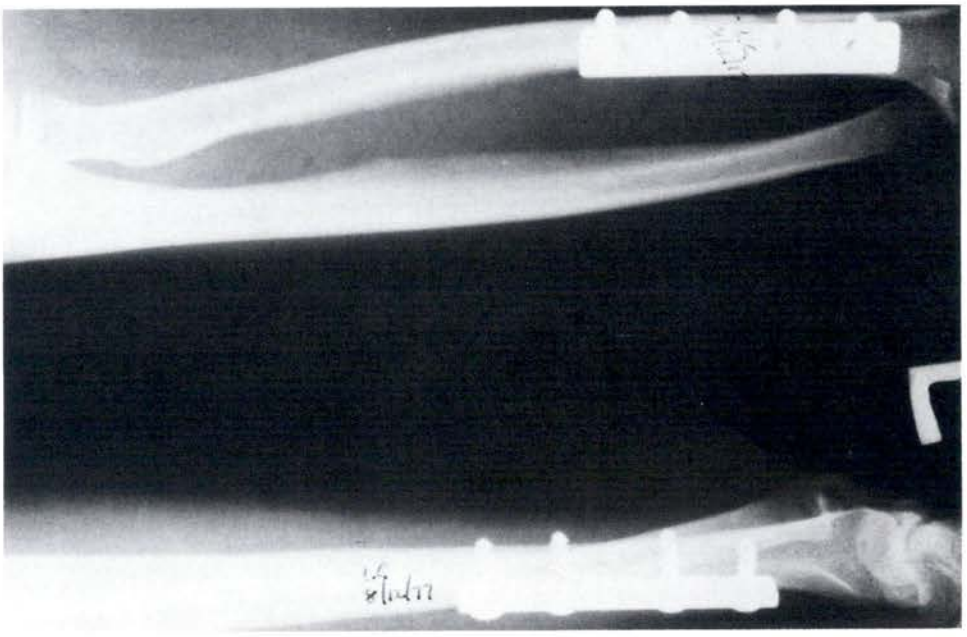
The ligamentous structures at the distal radioulnar joint are left undisturbed, however a synovectomy of the joint or extensor tendons, as in a rheumatoid patient, may be carried out at the same time as the procedure.[7]

After routine closure, a splint or plaster of paris cast is applied. A drain may or may not be used. Postoperatively the immobilization period should be approximately four to six weeks. This may vary; however, in our series, the length of immobilization was from three to six weeks. At conclusion of the immobilization period, active motion and soaks were then initiated.

RESULTS OF DISTAL RADIOULNAR JOINT ARTHRODESIS AND CASE REVIEW

Eight cases were reviewed in this series, one of which will be presented at this time.

L.C.—A 25 year old caucasian female, had originally a Galeazzi type fracture of the left forearm in an automobile accident. She subsequently underwent an open reduction with internal fixation with A.O. plate. As the result of her injury and internal fixation she had marked restriction of pronation and supination as well as decreas-

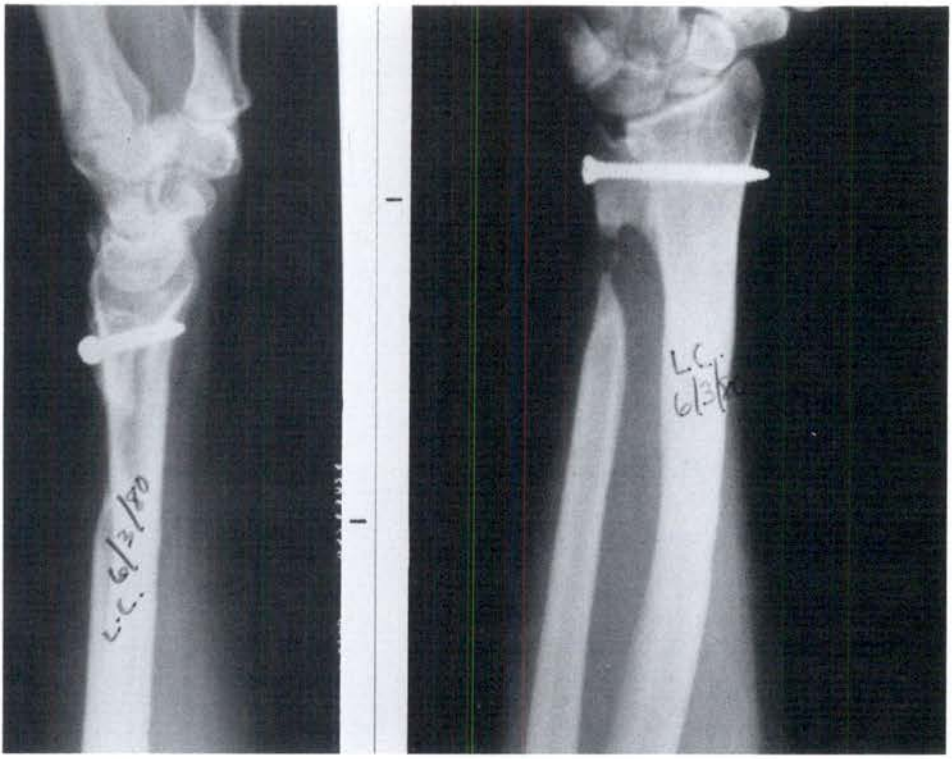


ed flexion and extension at the left wrist. She also had a very painful distal radioulnar joint with dorsal dislocation of the ulna.

Preoperatively she had 0 degrees of supination, 30 degrees of pronation, 0 degrees of active extension and 35 degrees of active flexion of the left wrist. The Lauenstein procedure was performed. On her last evaluation 24 months postoperatively, she had normal supination and pronation, 52 degrees of active flexion and 54 degrees of active extension of the wrist. She had no complaint of pain although she did claim some slight decrease in grip strength which was varified by dynamometer. Subjectively, she was very satisfied with her results.

however, postoperatively, she developed clicking and pain of the proximal stump necessitating ligamentous reconstruction, using a palmaris tendon graft which was sutured to the extensor carpi ulnaris tendon, with resultant marked improvement. At last evaluation approximately one and one half years post ligamentous reconstruction, her range of motion was excellent. The grip was very slightly decreased and the clicking and pain was absent. Cosmetically she was quite satisfied with her result. In retrospect, too much bone had been removed from the proximal portion of the ostectomy.

Fractures, Rheumatoid disease, degenerative osteoarthritis, radial impaction deformity and numerous other



DISCUSSION AND SUMMARY

Of the eight people who were treated by with the Lauenstein procedure, only one patient developed any problem. This was a 46 year old white female who had had pain and problems with a dorsal dislocation of her distal ulna with marked prominence. She had undergone the Lauenstein procedure; problems directly affect the function and cosmetic appearance of the distal radial ulnar joint.

Currently the accepted orthopedic treatment has largely been resection of the distal ulna. (Darrach procedure) This procedure is not without complication, which has been illustrated.

The Lauenstein procedure provides

TABLE I

Age & Sex	Reason & Etiology For Procedure	Preoperative Evaluation	Postoperative Evaluation	Length Of Follow Up
(1) 57 yr. male	Severe Rheumatoid arthritis and marked decreased range of motion. (supination and pronation)	Supination approximate 10°. Pronation approximate 10°. Dorsiflexion approximate 15°. Volar flexion 10°.	Supination full. Pronation full. Dorsiflexion approximate 60°. Volar flexion 45°.	13 Months.
(2) 25 yr. female	Galeazzi fracture with open reduction and internal fixation radius, pain and decreased range of motion.	Supination 0°. Pronation 30°. Dorsiflexon 0°. Volar flexion 35°.	Full supination and pronation. Volar flexion 52°. Dorsiflexion 54°.	24 Months.
(3) 28 yr. male	Comminuted fracture distal radius and ulna with open reduction and internal fixation distal ulna with pain and decreased range of motion.	Supination 65°. Pronation 70°. Dorsiflexion 20°. Volar flexion 30°.	Full pronation and supination. Volar flexion 72°. Dorsiflexion 62°.	2 Months.
(4) 46 yr. female	Dorsal dislocation of distal ulna with decreased range of motion and pain.	Supination 30°. Pronation 30°. Dorsiflexion 35°. Volar flexion 20°.	Full supination and pronation. Dorsiflexion 65°. Volar flexion 55°.	14 Months.
(5) 21 yr. female	Dorsal dislocation of distal ulna. Unacceptable cosmetically.	Supination 70°. Pronation full Dorsiflexion full. Volar flexion full.	Full Range of motion, supination, pronation, dorsiflexion and volar flexion.	26 Months.
(6) 20 yr. female	Dorsal dislocation distal ulna with pain at distal radial ulnar joint.	Full range of motion all planes (painful).	Full range of motion all planes. (No pain)	18 Months.
(7) 24 yr. male	Fractured ulnar styloid and dorsal dislocation distal ulna. Pain with decreased grip at wrist.	Supination 0°. Pronation 30°. Dorsiflexion 75°. Volar flexion 75°. Poor grip strength.	Supination 60°. Pronation 90°. Increased grip. Full dorsiflexion and volar flexion.	62 Months.
(8) 33 yr. male	Mal-alignment with radial impaction after fractured distal radius and ulna with decreased grip, dorsal dislocation distal ulna with pain.	Supination approximate 20°. Pronation approximate 15°. Dorsiflexion approximate 5°. Volar flexion 20°.	Increased grip. No pain. Dorsiflexion 65°. Volar flexion 30°. Pronation full. Supination approximate 60°.	7 Months.

stability and properly aligns the distal radioulnar joint as well as forming a pseudoarthrosis of the distal ulna to increase range of motion, especially supination and pronation of the forearm, which may have been markedly restricted. In our series of eight patients we feel our results have been quite satisfactory. All improved their range of motion dramatically. The cosmetic appearance of the wrist was markedly improved. Only one patient had any problem and this was sited as above. The pain was greatly relieved and this was the main goal of the operative procedure.

It is our opinion the Lauenstein procedure is not overly difficult to perform and offers an excellent alternative to other treatments for various dysfunctions of the distal radioulnar joint.

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Treatment of Acetabular Fractures: Clinical Review of 29 Fractures

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ABSTRACT: The results of treatment of twenty-nine acetabular fractures in a general hospital over five years is discussed. Adequate assessment and classification was a problem in the initial cases. Judet and Letournal views of the pelvis as well as computerized tomographic scans added greatly in the assessment of acetubular fractures. A classification system was adopted and made treatment much more relevant.

Twenty-four patients were involved in vehicular accidents and five patients had sustained falls. The average age was forty-seven years. Ten of the twenty-nine patients had other major injuries. Three patients had posterior dislocation of the hip and two of the three had a persistent foot drop two years post injury. Nine of the twenty-one patients treated conservatively did well. Six patients required open reduction and internal fixation of their acetabular fractures. Of these, two went on to have total hip arthroplasty and two of the six patients had an excellent result. Hospital stay was shorter in the operative group. **KEY WORDS:** Acetabular fractures, Judet- Letournal views of the pelvis, classification of acetabular fractures, open reduction, internal fixation of acetabular fractures, AO technique.

INTRODUCTION

Acetabular fractures are relatively uncommon fractures and hence are usually poorly understood by many orthopedists. In the literature there are proponents of conservative treatment of acetabular fractures[1] and others recommend operative treatment.[2,3] Some orthopedists treat all types of acetabular fractures conservatively hoping to achieve a good functional result. If a good result is not obtained many are quick to perform a resurfacing procedure for having failed initially to achieve anatomic reduction.

These fractures are usually the result of vehicular accidents or other major trauma. They may be associated with dislocation of the hip and fracture of the femoral head. Since these fractures are intra-articular and are often displaced, accurate reduction and early motion is needed if degenerative joint disease of the hip is to be minimized. Moreover, many times these patients have other major injuries and degenerative types of diseases which greatly influences treatment. In this paper the results of treatment of twenty-nine acetabular fractures over a five year period with at least a two year follow up is presented.

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EVALUATION OF ACETABULAR FRACTURE

In order to manage an acetabular fracture, an accurate radiological assessment must be made of the fracture and especially to determine if there is any displacement of the articular surface. Judet and Letournal have described a method using A.P., lateral and two oblique projections of the pelvis to delineate the important landmarks of the acetabulum. This is illustrated by Figure #1.

Figure 1.

Tomograms are helpful in determining displacement of the articular fragments and associated femoral head fractures if computerized tomographic scans are not available. Figure #2.

Computerized tomographic scans are extremely useful in assessment of acetabular fractures. One can see the extent of the fracture lines, the size of any displaced fragments, relationship of the femoral head to the acetabulum, and fractures of the femoral head. It is the best method of determining whether or not conservative or surgical treatment is necessary and is valuable in planning the surgical approach and types of internal fixation needed to achieve anatomical reduction. Computerized tomographic scans are also helpful in assessing the healed acetabular fracture in regards to prognosis and the need for secondary procedures. Figure #3.

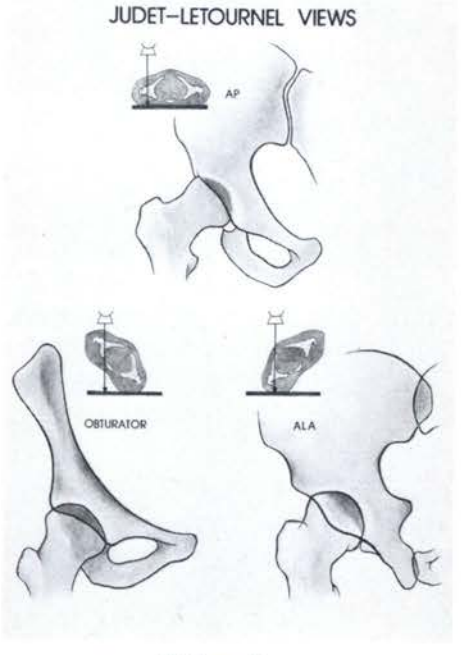

Figure 2.

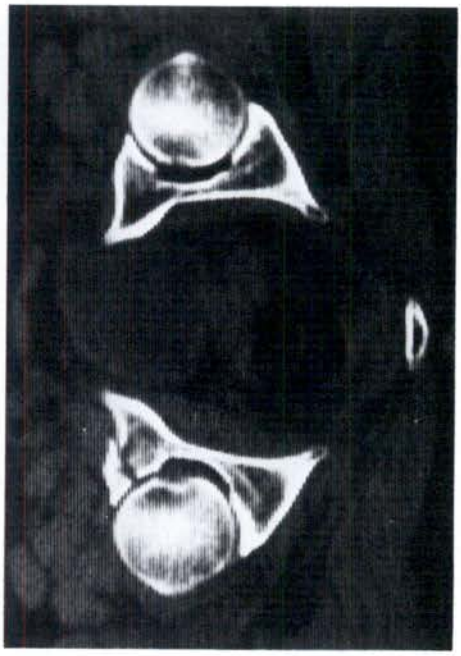

Figure 3.
Note the fracture anterior aspect of the acetabulum on the left with minimal displacement. This can definitely be treated conservatively.

CLASSIFICATION OF ACETABULAR FRACTURES

Various classification systems have been proposed and many are difficult to understand and apply to particular clinical situations. Judet and Letournal have devised a complete and easily understood classification based on surgical anatomy of the acetabulum, mechanism of fractures, and pathological findings at the time of surgery.[4,5] Figure #4.

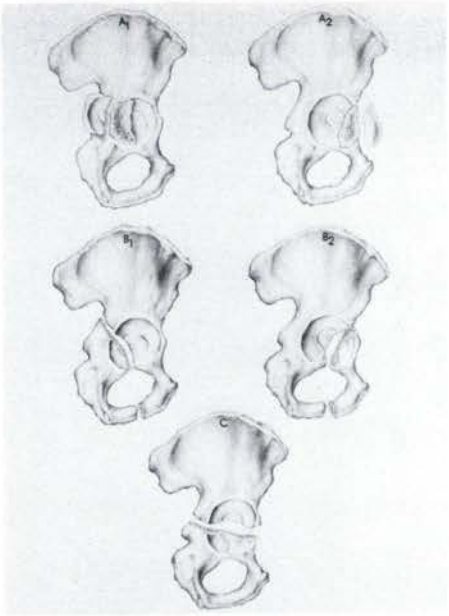

Figure 4.
Basic types of Acetabular Fractures.

TREATMENT OF ACETABULAR FRACTURES

If there is no displacement or minimal displacement of 1 to 2 mm. then a conservative approach is used. If there is displacement which can not be reduced by manipulation or traction then open reduction and internal fixation is indicated as with any other intra-articular fracture of a major weight bearing joint.

The surgical approach is dictated by the type of fracture and careful planning is needed. With the advances in instrumentation and methods of internal fixation of fractures, rigid internal fixation can be achieved. The goal of treatment of acetabular fractures is as near an anatomic reduction as possible.[6]

MATERIALS AND METHODS

A five year retrospective study was performed on twenty-nine patients with acetabular fractures treated at Doctors Hospital, Columbus, Ohio with a minimum follow up of two years. These patients were treated by one of seven staff orthopedists. There were seventeen female patients and twelve males. All fractures were unilateral. The age range was fifteen years to eighty-two years and the average age was forty-seven years. There were sixteen right acetabular fractures and thirteen left. Twenty-four patients were involved in vehicular accidents and five patients had sustained a fall. In the majority of patients who had a fall the mechanism of injury was a fall on the ipsilateral side with a force generated through the greater trochanter and resulted in a Type C fracture. The types of the twenty-nine acetabular fractures are shown below:

TYPES OF FRACTURES

A_1 — 4	
A_2 — 0	
B_1 — 7	Combination Fractures
B_2 — 1	C + A_1 — 4
C — 11	B_1 + B_2 — 2

Conservative treatment generally consisted of bed rest and traction for four to six weeks, toe touch ambulation with crutches or walker for four to six weeks, and then weight bearing to tolerance. Six patients were treated with skeletal traction and one of those also required a lateral traction pin to achieve satisfactory reduction.

The surgical exposures for acetabular fractures are the posterior, ilioinguinal, and iliofemoral approaches.[3]

Surgery was performed from six hours post injury to eighteen days post injury. The average time from injury to surgery was five and one-half days. Four patients required the posterior approach and two patients had combined iliofemoral and posterior approaches. Ten of the twenty-nine patients had other major injuries such as laceration of the liver, fracture of the transverse process of the lumbar spine, cerebral concussion, C_2 fracture, fractured shoulder, fractured ankle, cruciate ligament tear, foot drop, tibial plateau fracture, orbital fracture, and metatarsal dislocations.

Six of the twenty-nine patients required open reduction and internal fixation. Two patients had B_1B_2 fractures

Figure 5.
Preop X-ray.

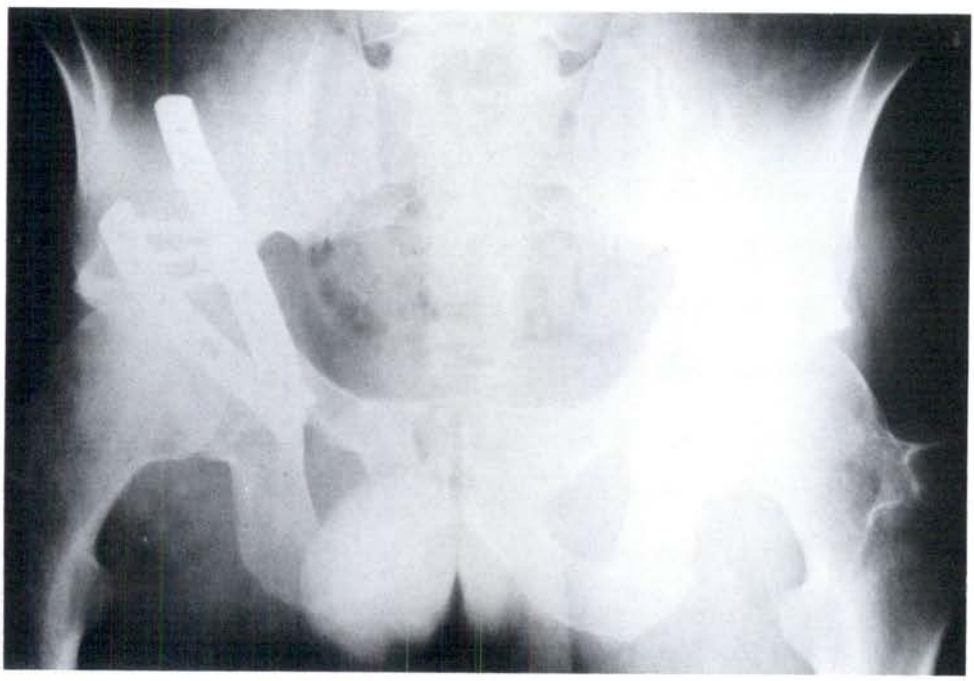

Figure 6.
Postop X-ray.

Figure 7.
Preop fracture — Dislocation of the hip.

(Figure #5 and #6 pre and post operative A.P. x-ray), three had A_1 fracture plus posterior dislocation of the hip, (Figure #7 and #8), and one patient had a B_1 fracture. These were considered to be displaced fractures and the three A_1 fractures were considered unstable hips following reduction of the dislocation. Two of the three patients with A_1 fracture-dislocations of the hip had a foot drop on initial examination. The two patients with a foot drop had exploration of the sciatic nerve at the time of open reduction and internal fixation and were only contused. The foot drop has persisted at more than two years post trauma in both of these patients.

Four patients have required total hip arthroplasty following their acetabular fracture. Two of the four patients were treated conservatively in traction. Of the two patients treated initially with open reduction and internal fixation, one had avascular necrosis of the

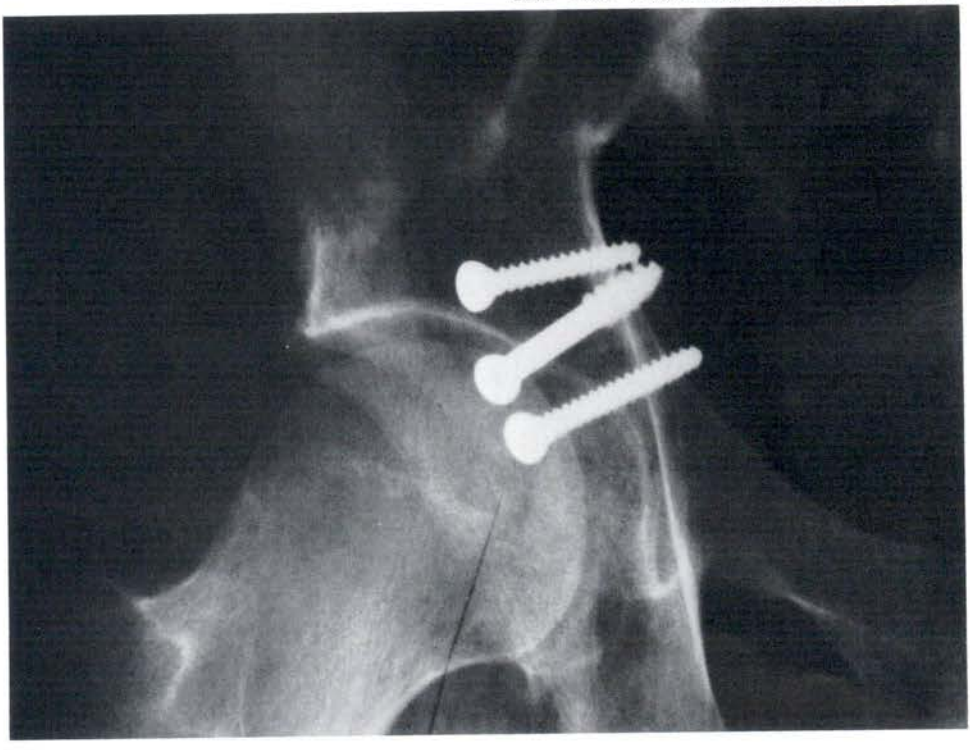

Figure 8.
Postop Fracture — Dislocation of the hip.

femoral head three months post trauma. The other required total hip replacement due to persistent pain and limitation of motion one year status post inadequate open reduction and internal fixation of the acetabulum.

Two patients died while undergoing conservative treatment. One patient, age seventy-six, had multiple fractures and died as a result of complications associated with a chronic pulmonary condition. The other patient, age eighty-nine, died three days after fracture of generalized debilitation. Follow up of the remaining twenty-seven patients reveals the following: Of the twenty-one patients treated conservatively two had total hip replacement, five required analgesics for pain, three had significant decrease in range of motion, and two required assistive devices. Nine of the twenty-one patients did well. Of the six patients treated with open reduction and internal fixation two had total hip replacement, one required analgesics for pain, two had decreased range of motion, and two required foot drop braces. Two of the six patients had excellent results. Since most of these patients had multiple injuries, hospital stay could not be compared accurately. However, the group having open reductiona and internal fixation had shorter stays than the group treated by conservative means.

DISCUSSION

One cannot stress enough the importance of adequate x-ray and a classification system in the successful treatment of acetabular fractures. Review of the x-rays with a radiologist along with the classification system and even a model of a pelvis can be very helpful. Nondisplaced fractures are treated conservatively while displaced fractures and especially unstable fracture-dislocations are treated with open reduction and internal fixation. Some displaced fractures can be treated with manipulation and skeletal traction if reduction can be achieved. The end results of acetabular fractures treated conservatively vs. operatively can not be truly compared due to the comminution and displacement of the operative cases.

The surgery should be performed as soon as possible, depending on the patients medical condition, hopefully within the first three weeks. Orthopedic surgeons using anterior and posterior approaches for total hip arthroplasty and endoprosthesis need little review of the anatomy and surgical approaches. If an anterior and posterior approach is required, probably two orthopedic surgeons working simultaneously will decrease the operating time and make the reduction easier. In this instance the patient is positioned in the lateral recumbent position. Blood loss has not been a problem.

In markedly comminuted fractures one must be sure to clear out as much debris as possible from the joint and also check for fracture or injury to the femoral head.

Even if the surgeon is familiar with proper AO technique in open reduction and internal fixation of long bone fractures, bending and twisting the plates to contour to the pelvis may take some special attention. Hospitalization has been shortened in operated patients and the possibility of mobilization of other joints has been greatly enhanced. In this study the average age was forty-seven years and everything possible should be done to restore as anatomically as possible the acetabulum to prevent degenerative joint disease and its sequela.

CONCLUSION

1. An adequate assessment of acetabular fractures can be achieved with Judet and Letournal views and computerized tomographic scans.
2. A reasonable classification system must be used to determine the course of treatment.
3. Nondisplaced or reducible fractures are treated conservatively.
4. Displaced or unstable fracture-dislocations of the acetabulum should be treated with open reduction and internal fixation.

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The Reverse Dermal Graft: A Procedure for Reconstruction of Nail Bed Avulsions

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Edward F. Burke, D.O., Detroit, Michigan

ABSTRACT: The reverse dermal graft is a procedure for revision of fingertip injuries, that have retained a viable germinal nail matrix and loss of the nailbed. The reverse dermal graft allows for adherence of the new nail to the graft, added strength, and a satisfactory cosmetic appearance. **KEY WORDS:** Reverse dermal graft, germinal nail matrix, nailbed, Finger tip avulsions.

INTRODUCTION

The treatment of fingertip injuries that involve partial or complete loss of the nail bed, with a viable germinal nail matrix, has been an infrequent subject in the literature. We present here a procedure, the reverse dermal graft, for repair of these nail bed injuries that gives a functionally and cosmetically good result. This technique is attributed to H. E. Kleinert, M.D., et.al., Louisville, Kentucky.[4] We will review seven cases in this report.

The nail is of ectodermal origin and composed of cornified epithelial cells. Its growth originates from the germinal nail matrix and grows out over the nail bed to which it is firmly adherent. The nail provides a protective covering to the dorsal, distal finger and functionally provides resistence to the volar pad during intricate hand functions.[3]

In 1954, Haynes reported that a full thickness skin graft minus its epithelial surface, will take as a free graft when applied dermal side down on a recipient bed.[2] His reasoning for survival of this type of graft on a relatively avascular bed is that the comparatively few larger vessels in the deeper dermis become numerous small vessels towards the surface, therefore, the chance for vascular anastomosis is increased.[2,5] Clodius stated that the reverse dermal graft was thin, yet provided properties of good mechanical resistance.[1]

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PROCEDURE

This procedure is done under tourniquet control. Meticulous cleansing of the wound site is performed and clear sharp margins of any remaining nailbed are created. A defect of tissue on the volar or distal aspect of the fingertip is reconstructed using a V-Y advancement flap. The graft is usually taken from the groin or proximal forearm. With a small dermatome, the epidermal layer is elevated over an appropriate area and turned over like a trap door. (Fig. 1)

Figure 1.
Elevation of the Epidermal Flap

The full thickness dermal graft is then harvested. The defect in the dermal layer is closed primarily with fine inverted absorbable sutures, then the epidermal flap is turned back over the defect and sutured in place to minimize the scar. (Fig. 2) The reverse dermal graft is then applied to the defect in the nailbed with 6-0 non absorbable sutures with the dermal side down.

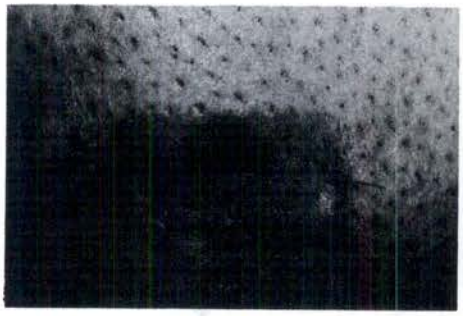

Figure 2.
The full Thickness Graft has been harvested and the Epidermal flap sutured in place.

Figure 3.
The full Thickness Graft is applied to the nailbed defect, dermal side down.

(Fig. 3) Great care is taken to approximate the edges of the graft and remaining nailbed with as perfectly a congruous surface as possible. Hemostasis should be complete prior to application of the graft and if this is not obtained a stent dressing should be applied over a non-adherent dressing. A bulky compressive type hand dressing is then applied. The stent dressing should be removed on the seventh post-operative day and the graft site is kept moist with soaks and antibiotic ointment while the nail grows out.

CASE REPORTS

CASE I: A forty-one year old Caucasian male sustained a dorsal oblique fingertip amputatin of the right middle and ring fingers. (Fig. 4) He had almost complete avulsion of the nailbeds with the distal phalanx exposed. A volar V-Y advancement flap was used to repair the loss of the volar and distal pulp and a reverse dermal graft was used to repair the nailbeds (Fig. 5a,b.) Postoperatively the patient did well.

CASE II: A fifty-three old Caucasian male presented with a partial avulsion injury of the nailbed and soft tissue volar pulp laceration of the right middle finger. A central defect involving a distal 50 to 60 percent of the nailbed was present. The volar pulp laceration was repaired and a reverse dermal graft was applied to the defect in the nailbed. (Fig. 6) The patient's post-operative healing was without incident.

Figure 4.
Case 1, showing soft tissue injury of the right ring and middle fingertips.

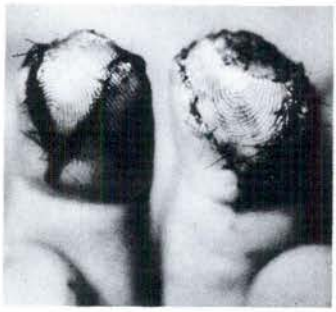

Figure 5a.
Case I immediate postoperative appearance.

Figure 5b.
Case I immediate postoperative appearance.

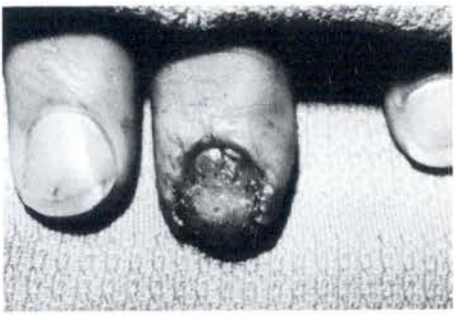

Figure 6.
Case II the size of the Graft Applied.

CASE III: A nineteen year old Caucasian male sustained a radially based oblique amputation of the right thumb tip with a portion of the distal phalanx exposed. Approximately 25-30 percent of the distal nailbed was avulsed. The exposed bone was well contoured and then a V-Y volar advancement flap was used for the pulp defect. A reverse dermal graft was used to repair the nailbed defect. The patient went on to heal without complications.

CASE IV: A nineteen year old Caucasian female presented with a one month post avulsion injury to the right thumb tip. On examination the distal half of the nailbed was avulsed with secondary granulation tissue and infection. In surgery the wound was thoroughly debrided and a reverse dermal graft was applied. The patient did well post-operatively.

CASE V: A nineteen year old Caucasian female had a crush injury to the right index fingertip. After thorough debridement, a one centimeter defect of the nailbed was present. A reverse dermal graft was used to repair the defect and the patient went on to heal uneventfully.

CASE VI: A thirty nine year old Caucasian female sustained a crush injury to the tip of the left index finger with avulsion of the distal two thirds of the nailbed. Again, a reverse dermal graft was used to repair the defect in the nailbed and healing was without complications.

CASE VII: A twenty four year old Caucasian female has a crush injury to the tip of the right index finger resulting in a dorsal oblique amputation. Approximately the distal half of the nailbed was avulsed. A V-Y advancement flap was used on the volar aspect to reconstruct the defect in the pulp tissue and a reverse dermal graft was used to replace the nailbed. The patient went on to heal without complications.

RESULTS

All seven of these patients were followed postoperatively until complete healing was obtained and the nail had grown out. Each new nail was well adhered to the underlying graft and had a smooth, well contoured appearance. Of the seven patients, only two were available for long term re-evaluation, Cases I and II. In Case I, the nail of the ring finger was perfectly smooth and well contoured, and the nail of the middle finger developed a longitudinal ridge. (Fig. 7a,d) In Case II, a smooth, well contoured nail can be seen. (Fig. 8a,b) All of the patients were very satisfied with the results.

Figure 7a.
The final postoperative result of Case I.

Figure 7b.
The final postoperative result of Case I.

Figure 7c.
The final postoperative result of Case I.

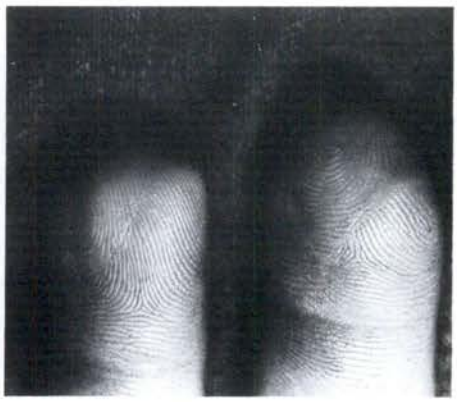

Figure 7d.
The final postoperative result of Case I.

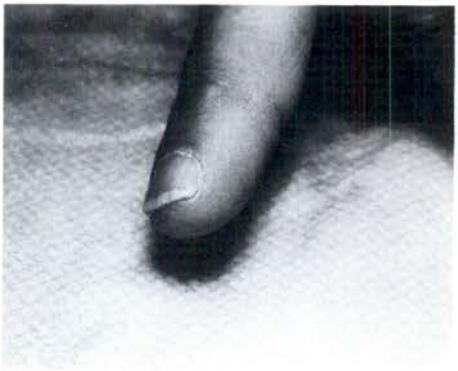

Figure 8a.
The final postoperative result of Case II.

Figure 8b.
The final postoperative result of Case II.

DISCUSSION

We feel that the reverse dermal graft is an excellent procedure for treatment of nailbed avulsion injuries. It provides an essentially normal appearing nail that is fully functional because of its firm adherence to the underlying graft. This procedure also allows the surgeon to retain added length of the distal phalanx in fingertip amputations.

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Medial Shelf Syndrome
Review of the Literature and Case Report

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ABSTRACT: This paper reviews a relatively common yet frequently overlooked diagnosis of the "synovial shelf syndrome" involving the knee joint with major emphasis on clinical correlation with diagnostic evaluation and surgical findings. There will also be a brief review of the pathophysiologic mechanism including embriology and anatomy. **KEY WORDS:** Shelf-plica, pseudolocking, clicking, Vague pain.

INTRODUCTION

One of the most frequent problems seen by the community orthopedic surgeon deals with knee injuries including pain, clicking, and vague instability of the knee joint. Previously, these problems had been diagnosed as "internal knee derangements" most frequently accompanied by findings of torn menisci, joint bodies or patella instability, for which there were no clear cut clinical criteria to make an appropriate diagnosis. Standard x-ray examinations and even specialized x-rays such as double contrast pneumoarthrography, frequently fail to reveal the pathology. Recently, with the development and modernization of the arthroscope, the arthroscopist and orthopedic community in general have become increasingly more aware of another entity mimicking the "internal knee derangement." This has been described by several authors over the last ten to fifteen years and called the "Synovial Shelf Syndrome" (Broukhim et. al.) the "Medial Plica Shelf Syndrome" (Mital and Hayden[5]) and simply "The Plica Syndrome of the Knee" (Hardaker, Jr. et. al.)

The presence of a thickened synovial shelf of the knee joint has been recognized by anatomists for a number of years. Iino first described it in 1981, Mizumachi and Associates[6] brought further attention to this finding in 1948 and it has since been described by others. Although this entity has been variously reported in the orthopedic literature, it is still relatively unknown by the orthopedic surgeon.

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CLINICAL

The clinical findings associated with this syndrome include vague pain and discomfort in the knee with pseudolocking and clicking[3]. True locking of the joint however, is not usually a feature of this syndrome and helps in the differentiation between the shelf syndrome and a true meniscal tear. This seems to occur mostly at approximately twenty to forty degrees of flexion[9]. There is frequently tenderness at the patella femoral joint on the medial side to palpation. There may be "a palpable click" within the knee with the Apley test at varying degrees of flexion and entension. Routine x-rays are negative and arthrography is often negative as well. The true diagnosis can only be made by an experienced arthroscopist with a high index of suspicion at the time of the arthroscopy[1]. This is the reason for the lack of diagnosis in many cases since most of the clinical findings in these cases are subjective on the part of the patient who may be written off by the examining physician as a malingerer. Most of the symptomatic shelf syndromes are due to direct contusion of the flexed knee as in falls and dashboard injuries.

EMBRIOLOGY, ANATOMY AND PATHOPHYSIOLOGY

The medial synovial shelf is one of three synovial plicae found within the knee joint. These are known anatomically as the plica synovials suprapatellaris, splica synovialis infrapatellaris, and plica synovialis mediopatellaris. Their origin is thought to develop embriologically from a failure of complete coalescence of the medial, laterial, and suprapatella recesses that are formed during embriologic development[4]. The result of failure to form a confluent suprapatella bursa will frequently leave thickened synovial septi which have been designated to be these synovial plica. Studies have shown that in 78% of adult knees, there is a residual suprapatella synovial plica or variant[8]. Most of these apparently are subclinical in nature and therefore, cause no problems or confusion except when the condition becomes symptomatic.

The condition becomes symptomatic when there is blunt trauma causing inflammatory reaction associated with edema and thickening[3]. At this time, the plica can become firm and inelastic due to thickening during normal knee motion. The thickened band-like material will frequently snap between the medial femoral condyle and the patella causing a cyclic reaction adding to further inflammation, scarring and thickening. It is this thickened band-like shelf which causes the clinical symptomatology.

CASE EXAMPLE

A typical example of the condition we are describing was found in a patient M.S. who was examined for a chief complaint of pain and discomfort in the left knee resulting from a fall at a shopping center. The patient apparently fell directly on her knee and was taken to a local hospital where x-rays were taken and reported as normal. The patient subsequently came to our office for evaluation. At the time of the patient's initial evaluation, it was obvious that there was litigation involved and the patient was initially thought to be looking for secondary gain from an apparent trivial problem. The patient was continually evaluated in the office and treated conservatively. When, after many months, she continued to have continual and consistent complaints, it was felt that a double contrast arthrogram should be performed in order to rule-out the possibility of a medial meniscal tear or other "internal knee derangement." This was done by a highly experienced arthrographer and reported to be completely normal confirming our initial impressions. Approximately one year later, because of continual symptomatology, the patient was admitted to the hospital for a diagnostic arthroscopy, the results of which are seen in (figure #1). This demonstrated a

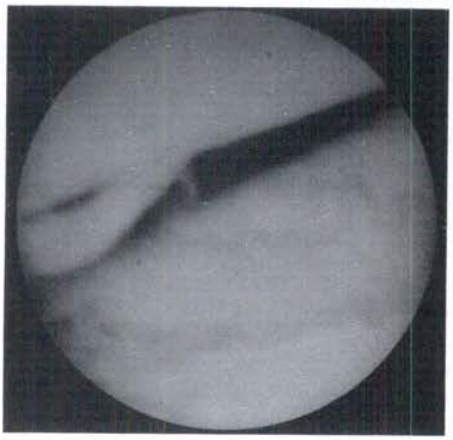

Figure 1a.
Arthroscopic view of medial patella plica between the patella and the medial femoral condyle.

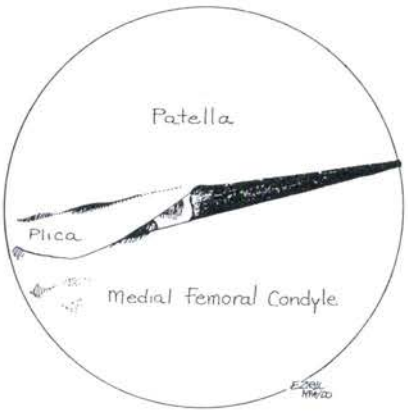

Figure 1b.
Artists conception of 1a.

thickened band-like structure running over the medial femoral condyle between the patella and the femoral condyle that was fortuitously recognized as a medial patella plica and a tentative diagnosis of "shelf syndrome" made. The patient was then scheduled for surgery and an arthrotomy of her knee performed and a fibrous band measuring approximately three inches in length (figure #2) was excised confirming our initial impression. The band originated in the region of the suprapatella bursa and ran medially over the femoral condyle to insert into the synovial covering of the infrapatella fatpad, (figures 3 & 4). The patient made an uneventful recovery and has full range of motion of her knee and is completely asymptomatic at this time.

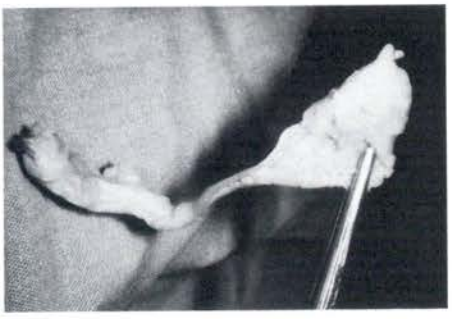

Figure 2.
Surgical specimen of medial patella plica.

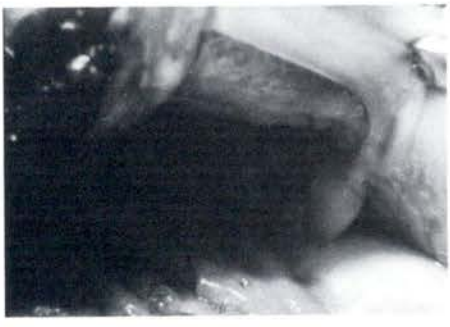

Figure 3a.
Medial patellar plica initial view with synovium retracted.

DISCUSSION

This case describes a typical example of the problems both in arriving at the correct diagnosis and with the timely treatment of same. The patient did have and describe typical symptoms of this syndrome including a feeling of locking and weakness in her knee and continued pain and discomfort. She had been evaluated by a number of physicians including the author, all of whom felt that this patient was over reacting to a trivial problem with the hopes of obtaining secondary gain. The true pathology was therefore overlooked. It was only due to the patient's persistent complaint and final arthroscopic collaboration that the ultimate apparently successful goal had been accomplished.

There is no doubt that there are many other patients being treated "conservatively" by their physicians including orthopedists in the general community who are unaware of this syndrome which is real as evidenced by (figures #1-4) above. It is hoped that with the continued interest in arthroscopy within the orthopedic community that this syndrome will be more readily recognized and treated properly.

SUMMARY

The medial shelf syndrome is a clinical entity which does exist. it is frequently unrecognized by practitioners within the general orthopedic community, primarily due to their lack of knowledge of the condition, and until the recent development and refinement of the arthroscope, lack of ap-

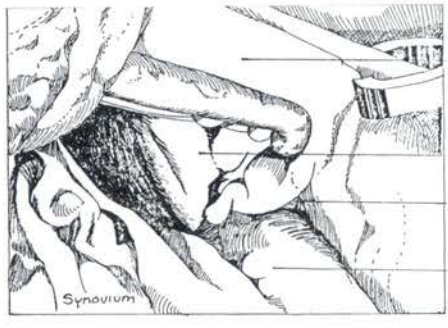

Figure 3b.
Artists conception of 3a.

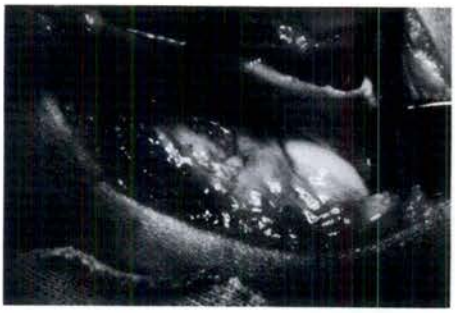

Figure 4a.
Partially removed plica still attached to synovial covering of the infrapatella fat pad.

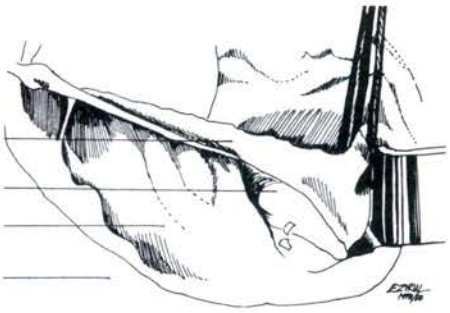

Figure 4b.
Artists conception of 4a.

propriate diagnostic methods being available. This pathologic condition of the knee can be satisfactorily treated with uniformly good surgical results. Appropriate treatment, however, must await and rely upon proper diagnosis which can only be made through knowledge of the existence of the problem and utilization of the appropriate diagnostic tools.

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Acute Psuedogout: A Case Complicated by Septic Arthritis

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ABSTRACT: An unusual association of acute pseudogout complicated by septic arthritis is presented. **KEY WORDS:** Acute pseudogout, septic arthritis, CPPD crystal, polarized light.

INTRODUCTION

Many types of arthritis may present to the clinician during his daily practice. Careful examination and study are necessary to make an accurate diagnosis in an effort to initiate proper therapy. This is particularly true when faced with an acutely inflamed joint. These joint attacks may be clouded by single joint involvement, incomplete or vague history, and superimposed pathology over prexisting arthritis. The following case presentation is an example of such a problem.

CASE PRESENTATION

An 84 year old white male chiropodist-podiatrist was admitted to the hospital via the emergency room with an acutely inflamed and swollen right knee joint. Despite his age, the patient is still in active practice, and participates in a great deal of self treatment. He has been in good health throughout his life except he has been treated for "gout" for a number of years with intermittent and varied medications. The focus of his arthritis seemed to be the right knee joint which produces intermittent dull aching pain and effusion. Three (3) days prior to his admission he had ingested a good deal of health foods and given himself his weekly B_{12} injection. Feeling renewed, he went out and shoveled snow from his driveway. He prepared himself by loosening up his right knee with fifteen (15) or more deep knee "squats" without any particular discomfort. Approximately ten (10) hours after this activity, he developed dull aching pain in the right knee which gradually began to swell. Thirty-six (36) hours later his knee was very swollen, errythematous, and tender. He tried to gain relief by injecting B_{12} around the joint, and he performed acupuncture on himself by inserting the acupuncture needles at various locations about the knee joint. Forty-eight (48) hours later the swelling and intense pain limited his range-of-motion, and he could no longer bear weight on his right lower extremity. At this time, he reported to the emergency room.

Examination revealed a well oriented, well nourished, well hydrated, white male with intense right knee pain. His temperature was ninety-nine and nine-tenths (99^9), and his vital signs within normal limits. The right knee was held at forty-five (45°) degrees of flexion, and the patient resisted violently active or passive range-of-motion due to the severe pain produced. There was marked effusion in the knee joint. (See photographs) The skin about the knee joint was shiny, quite warm, and errythematous. Palpation of the joint was unrewarding as diffuse tenderness was present at each structure examined. Examination of the hands revealed thenar, hypothenar, and intrinsic muscle atrophy. Heberdin's and Bouchard's

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Anterior and lateral views of the right knee

Note: Marked swelling and erythema

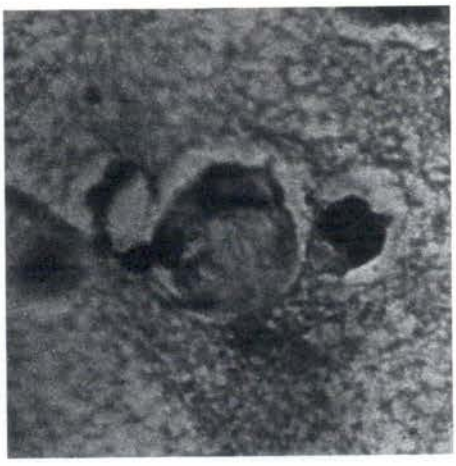
nodes were present as hypertrophy at the distal and proximal interphalangeal joints of all fingers, but no deviation or subluxation was noted. (See photographs) Movement of both wrist joints was moderately discomforting to the patient. Remainder of the structural examination reveals mild increase normal kyphotic curvature of the thoracic spine with marked decrease in range-of-motion of the spine. Further physical examination reveals bilateral arcus sinilus with Keith-Wagner I fundiscopic changes in both eyes. The patient was edentulous with no mucosal lesions in the mouth. There was a mild increase in the anteroposterior diameter of the chest. The heart was regular in rate and rhythm without murmurs. Lungs clear to ausculation. Abdominal examination was unremarkable.

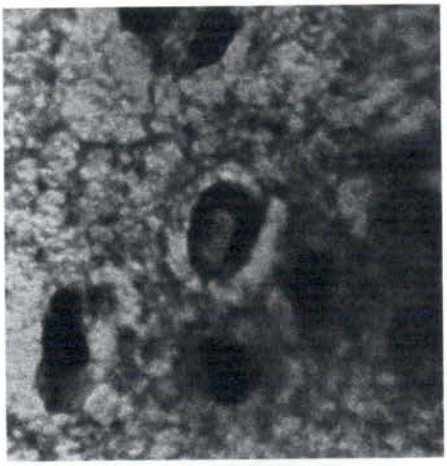
In the emergency room, arthrocentesis was performed, and an unknown amount of fluid aspirated. Synovial fluid analysis, performed by a technician, reported no crystals. WBC 13,000/cc with differential of all Polymophonuclear neutrophils. Gram stain of the synovial fluid was negative for bacteria, and the fluid was submitted for culture and sensitivity. Serum uric acid 3.0 mg %. CBC revealed 12,200 WBC with "left shift" of the Schilling index.

The patient was examined by the Orthopedic Department late the same afternoon on the floor. Eighty (80) cc amber-yellow-white fluid with many large white flakes and white sediment was aspirated. Synovial fluid analysis revealed a Glucose 15 mg % (serum 190 mg %), and a cell count of 15,000 cc (all PMN). The pathologist reported

Dorsal view of right and left hand
Note: Note interosseous muscle atrophy

Heberdin's and Bouchard's nodes





Photomicrographs: (A & B) Synovial fluid under polarized light showing CPPD crystal

(C & D) CPPD crystal within WBC on gram stain

many intracellular and occasional extracellular Calcium pyrophosphate crystals were observed as slightly positive birefringent crystals on polarized light exam. (See photomicrographs) When the flakes settled from the fluid, a good mucin clot was formed with clear surrounding fluid. Gram stain was negative for bacteria, and aerobic and anaerobic cultures were submitted. Other laboratory findings were: VDRL non reactive, SMAC-WNL, acid phosphatase 0.6 Bodansky units, Serum protein electropherisis revealed elevation Alpha 1 0.54 AM % and Alpha 2 1.2 GM %.

Electrocardiogram was abnormal with bifasicular heart block. There was superior axis deviation suggesting left axis deviation and right bundle branch block. There was first degree AV junctional block with PR interval of 0.22 seconds.

X-ray examination of the knee reveals multiple calcifications in the soft tissues about the right knee, some posterior and some in quadriceps mechanism. Punctate calcifications within the knee joint which appear to be within the menescus. A small linear foreign body was displayed in the soft tissues immediately adjacent to the medial aspect of the mid portion of the medial femoral condyle. AP, lateral, and oblique projections of both wrists revealed multiple cystic areas of dimiralization of carpals and distal radius. There were calcifications between the carpal bones and the ulna. (See photographs of patient's radio-

graphs) There was mild to moderate osteophyte formation of all lumbar vertibrae with assymetry of the articular facets throughout the lumbar region.

ty (90) degrees. Both cultures were reported as scant growth of alpha streptococcus. The patient was again questioned about his acupuncture techni-

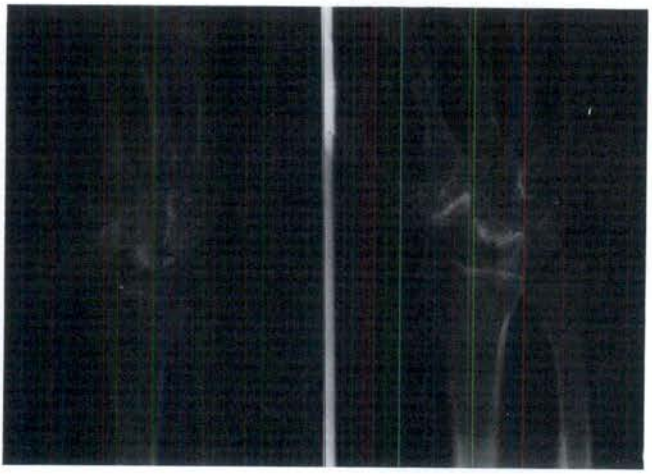
Anterior view right knee. Note: Linear calcificational lateral mensicus Foreign body medial condyle femur

Lateral view knee. Note: Calcification suprapatellar pouch, papliteal fossa, superior pale patella and patellar tendon

Lateral view knee. Note: Foreign body over femoral condyle

A diagnosis of acute psuedogout was entertained. The patient was placed at bedrest, the joint splinted, ice bags applied, and the right lower extremity elevated. The patient was given a loading dose of three hundred (300) mg phenbutazone then one hundred (100) mg every six (6) hours. The day following admission, the knee was less erythematous but contained eighty (80) cc effusion. Patient remained slightly febrile (99^6). Laboratory reported one (1) colony growing in emergency room culture and five (5) colonies on the admission culture of an unknown bacteria. On the second hospital day, the patient was afebrile (98^4). Sixty (60) cc effusion was aspirated with range-of-motion increased fifteen (15) to nine-

que. he reported he "sterilized" his needles by placing them in his mouth and moistening them with saliva before inserting. Since the bacteria cultured from the fluid was normal flora from the mouth, and the metallic foreign body was near the knee joint, the patient was begun on Cephalothin, five-hundred (500) mg every six hours. The synovial fluid was recultured. Range-of-motion increased daily with gradual decrease in pain and errythema. The patient was begun on whirl pool treatments with active range-of-motion exercises. The third culture was reported as alpha streptococcus. The knee joint was aspirated daily for patient comfort with almost daily decrease in quantity of fluid as well as gradual clearing. The



Xray: Right wrist Note: Calcification between distal radius and ulna

patient remained afebrile. On the tenth (10) day, he began walking with a walk-aide with partial weight bearing. Joint aspiration became less frequent, and the character of the fluid became turbid amber fluid. On the sixteenth (16) hospital day, a fourth culture was obtained, and was sterile. Patient was subsequently dismissed from the hospital on the eighteenth (18) hospital day with prescriptions for phenylbutozone, one hundred (100) mg twice daily, and instructions to limit activity until synouitis was further resolved.

DISCUSSION

The acutely inflamed joint can present a relatively complex diagnostic problem. Through a systematic interpretation of basic laboratory and synovial fluid analysis, an accurate diagnosis can be made and appropriate treatment administered. As seen from the case presented, an acute joint can be produced by one disease, and later complicated by another problem which in itself can cause an acute arthritis.

This patient seemed to precipitate an acute attack of psuedogout through abnormal exercise. In an attempt to relieve his pain, the patient produced a secondary septic arthritis with his acupuncture needles and B_{12} injections in the knee joint. This further trauma increased inflammation in his joint already inflamed from acute psuedogout creating an alarming clinical picture.

Psuedogout seems to have a predilection for the male population (1.35 to 1) in the older age group. The mean age of seventy-two (72) is given by McCarty! The disease is hallmarked by the presence of a biaxial crystal, calcium pyrophosphate dihydrate (CPPD- $Ca_2 P_2 O_7$: $2H_2O$) in the synovial fluids and soft tissues about the involved joint. The deposit of these crystals, symptomatic or non-symptomatic, has led many authors to coin the term Calcium Pyrophosphate Deposition Disease (CPDD). Also, in the past, some texts have referred to these deposits as chondrocalcinosis.[2] It would seem that Calcium Pyrophosphate Deposition Disease would encompass all of these entities, and should be used in its description.

The cause for CPDD remains unknown although several mechanisms have been proposed. It has been shown that synthetic or natural CPPD crystals injected into human or canine joints will cause acute arthritis.[7] Furthermore, trauma seems to intensify local CPPD deposition.[8] Since the concentration of crystals and calcium ions do not exceed the solubility product of the fluid, it is unlikely the crystals are actively formed in the joint fluid.[1] McCarty maintains that the perilunar deposits of CPPD crystals in the cartilage rupture into the lacunae of the cartilage due to trauma of some sort. This causes death of the chondrocyte, and loss of cartilage with resultant coalesence of CPPD crystals. If the concentration of crystals is superficial enough, they rupture into the joint, and there is a crystal induced synouitis.[1] Since this is a mechanical process, it is difficult to reverse or prevent crystal deposition or release into the joint. The inflammatory response is dose related, and produces a vasoactive or chemostatic factor activation leading to lecehocytis being drawn to the joint. The luehocytis phagocytize the crystals, and may rupture with some leposnal enzyme release.[5] This may cause further cartilage destruction with more crystal release and an ever increasing and perpetrating synovitis.

The clinical features of the disease are somewhat variable. The onset of signs and symptoms reach highest intensity twelve (12) to thirty-six (36) hours after the traumatic episode. Commonly, these symptoms may be noticed when the patient first bears weight in the morning! By far the most commonly affected joint is the knee. Although, the other large joints (hip and back) may be involved, and there is a likelihood of acute attacks recurring in previously involved joints. The acute attack does not seem to be as intense as gout, but the pain is more severe than has been observed with

gout.[8] The patient has a low grade temperature (99-101°). The involved joint is warm, swollen, errythematous, and very painful. Varying amounts of effusion are present. These patients may have other associated diseases such as Diabetes Mellitus, hyperparathyroidism, hemochromatosis, Wilson's Disease, acromegally, and perhaps gout. The attacks may last from twelve (12) hours to four weeks.

McCarty has observed several patterns of CPDD. Type A patients are characterized by complete resolution of inflammatory signs and symptoms, and affected joints are normal to physical exam between attacks. These patients are frequently falsely labeled gouty especially if hyperuricemia is present. McCarty maintained in a recent lecture that for every three (3) acute gouty attacks diagnosed, one patient has psuedogout or CPDD. Type B patients have almost continuous acute attacks, and are sometimes diagnosed as Thuematoic Arthritis especially if a number of joints are inflamed or involved. However, their RA factor is negative and CPPD crystals are present in the joint fluid.

Progressive chronic arthritis of large joints, especially the knee and/or hip with accompanying acute inflammatory episodes is seen in Type C. This is the most common presentation of CPDD, and the chronic arthritic changes are indistinguishable from degenerative joint disease (osteoarthritis). Type D patients resemble Type C but have no acute episodes. Both Type C and D patients commonly have flexion contractures of the joints.

When patients have radiographic calcification about the joint, as well as the cartilages, and are asymptomatic, the final Type E group of patients is formed.[1]

The criteria for the diagnosis of CPDD is based on the presence of CPPD crystals as the feature of the disease. Their definite or presumed presence leads to the terms "definite", "probable", and "possible" CPDD "Definite" disease if CPPD crystals have been demonstrated in tissues of synovial fluid by definite means, if crystal compatable with CPPD are present by polarized light and typical calcification appear on X-rays. The patient has "probable" disease if crystals present in fluid, or if typical calcifications appear on X-rays. "Possible" CPDD criteria are those patients with acute arthritis (especially knee) with or without concomitant hyperuricemia, or chronic arthritis (especially knee and hips) accompanied by acute exacerbations.[1]

Certain hereditary factors have been observed in CPDD leading to possible isolation of two (2) phenotypes. First, a polyarticular form seems to affect younger patients, and is rapid and progessive. While, the second form, is oligoarticular, slow and progressive, and seen in older people. These two (2) phenotypes may be sex linked as the daughters of affected fathers manifest the disease.

Radiographically, CPDD shows calcification around major joints (especially knee) with five linear calcifications in articular hyaline cartilage paralled to subchondral bone. The periarticular calcifications about the knee are best seen on the lateral view, and are located in the menisci, while, younger patients seem to have only one meniscus involved. It should also be noted that Baker found seven (7) percent of the population to have asymtomatic deposits in the menisci. Where as, Bennett and Weaver report five (5.6) to four (4.2) per cent respectively! These are described as diffuse and punctate. Other areas of calcification are articular disc of distal radioulnar joint, pubis, and annulus fibrosus of the intervertebral disc.

The laboratory is a great aide in making a differential diagnosis in CPDD. The Erythrocyte sedimentation rate (ESR) is elevated. CBC shows a leunocytosis (12-15.000/cc), with a "left shift" in the Schilling Index. Serum uric acid is usually normal. Serum protein electropherisis may show elevation in Alpha 2 and sometimes Alpha 1 globulin fractions due to chronic inflammation. Synovial

fluid analysis reveals a cloudy fluid which is amber to light yellow. It is less viscous than normal. The glucose level may be less than one-half the serum level, but not as low as seen in septic arthritis. There is a large number of nuetrophils (10-20,000/cc) with some monocytes. A mucin clot will form with the addition of acetic acid. Gram stain and culture reveal no bacteria. Microscopic examination with polarized light invariably show phogocytized CPPD crystals although some crystals are extracellular. These crystals show weakly positive birefringence as compared to the marked negative birefringence of Sodium urate crystals. These crystals appear as both monoclinic (unit cell with one obtuse and two right angles) and triclinic (units all with three obtuse angles), and twinning or pairing of the crystals is observed.

The treatment of the acute attack consists of bedrest with protection of the joint since any movement is extremely painful. The joint should be aspirated and irregated with normal saline to debride the joint of excess crystals and lessen the synouitis. Local inflammation may be decreased if a microcrystalline corticosteroid is instilled into the joint following aspiration. A nonsteroidal antiinflammatory drug is given in form of phenylbutazone three to six hundred milligrams loading dose followed by two to three hundred milligrams per day. Talbott reports a negative or equivocal response of CPDD to cholchicine while McCarty has been obtaining better results with this drug when given intravenously. Indomethacin, seventy-five (75) to one hundred and fifty (150) has also been used with fair results. As the acute symptoms subside, physical therapy can be used to decrease circulation to the joint in a whirl pool. Range-of-motion instruction and supervised exercise should be done to maintain motion at least zero to ninety degrees (0-90°). This should be done within the patients limits of pain and tempered by the knowledge that an energetic program may precipitate another acute attack.

CONCLUSION

A case of acute psuedogout or acute calcium Pyrophosphate deposition disease was presented followed by a discussion of the disease. It was previously reported that CPDD disease was associated with certain metabolic diseases. The case presented now relates the disease to iatrogenic septic arthritis. Even in the presence of two separate mechanisms, through systematic and specific history and physical examination and laboratory analysis, specific diagnosis can be made and appropriate therapy begun in patients with acute arthritis.

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Arthroscopic Surgery of the Knee — A Preliminary Report

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ABSTRACT: This is a report on cases treated with operative arthroscopy over the last three years. The conservative pre-operative care is explained along with the types of procedures done stressing the need for pre-operative care prior to surgery. Of 301 arthroscopies 178 included arthroscopic surgery. The procedures done included 70 meniscectomies, 23 chondral shavings with lateral releases, 37 synovial plica excision, seven chondroplasties, 18 patella or chondral shaving procedures, and 13 patients having multiple procedures done under arthroscopic control. The overall results were quite favorable indicating distinct advantages in that arthroscopic diagnostics is improved and arthroscopic theraputics decreases morbidity. Certain areas need more study, especially in the patello-femoral disease and early results are sufficiently encouraging to warrant dedicated promotion of the technical skills of arthroscopic surgery. **KEY WORDS:** arthroscopic visualization, operative arthroscopy, tissue injury.

INTRODUCTION

Diagnostic arthroscopy is rapidly becoming a routine procedure done prior to arthrotomy of the knee.[1] Technological advances in recent years have made arthroscopy a useful adjunct in diagnosis, treatment, and follow-up of knee surgery.[2] Some surgeons are now performing a major volume of knee surgeries totally under arthroscopic control.[3] The use of the arthroscope has decreased the morbidity in operating the more routine surgical problems, has added knowledge in visualizing the functioning knee; and has led to diagnoses previously not seen in arthrotomy.[4,5,6]

This is especially true for structures such as the fibrotic synovial plica which have been described in past literature, but no clear method of identifying its pathological status has been available.[7] With the arthroscope the plica can be seen pressing down on the femoral condyle in flexion; moderate degenerative changes can be seen in the condyle or in the synovium at the point of impact, thereby identifying the pathology.[8] The tracking of the patella can be seen through a suprapatellar pouch puncture thus assuring the need for a lateral release.[9] Synovial lesions can also be seen to impinge between the moving surfaces within the knee.[10] The alternative to arthroscopic visualization of these problems is dependence upon multiple x-ray evaluations which are difficult to reproduce and, therefore, unreliable.[11]

Though the advantages of arthroscopic surgeries have not yet stood the test of time, the early evidence suggests that a significant advantage in patient care can be expected through the use of this instrumentation.[12] The following is a preliminary report involving arthroscopic surgeries performed from August, 1978 to June, 1981.

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MATERIALS AND METHODS

In this study, the first meniscectomy done under arthroscopic control was a bucket handle tear operated in August, 1978. There were 267 participants in the series. A total of 301 arthroscopies

were done; 123 of them were not included because the arthroscopic procedure preceded an arthrotomy, in which no arthroscopic surgery was done, or only an arthroscopy was done. If an arthrotomy was performed with arthroscopic surgery also done, the procedure was included, (i.e., an arthroscopic excision of a lateral meniscus would be included in spite of the fact that a posterior medial arthrotomy was done to either excise or repair the posterior horn of the medial meniscus.)

All patients were from a single orthopedic practice and all were from one geographic area. The patients were not referred from long distances and virtually all of them presented themselves for treatment as they would to any general orthopedic practice. This factor is considered important based on the assumption that patients referred from other orthopedic surgeons, traveling long distances are less likely to expect or tolerate non-operative or conservative therapy with repeated follow-up prior to surgery. Thus the operative surgeon does not manage the pre-operative phase of the disease.

A concerted effort was made to exhaust conservative therapy (treatment) prior to surgery. In all but the most classically presenting knees, the patients averaged two office visits prior to surgery. Conservative treatment generally entailed regulating activities to avoid the discomfort about the knee, anti-inflammatory medications, as well as physical therapy, such as whirlpool, ultrasound, hot packs, and directed range of motion exercises. Failure of this type of therapy indicated surgery if the problem was felt to be amenable to surgical intervention.

Post-operatively, most patients were discharged the day following surgery. Those with lateral releases tended to remain hospitalized for a second day post-operatively, as did those with chondroplasty procedures. Very few patients remained longer than two days post-operatively. Even the markedly obese patients recovered to go home in one to two days. General instructions included training in the use of crutches, encouraging patients to bear weight as tolerated, and to eliminate crutches as soon as they were able to walk without pain. The patients who had undergone chondroplasty for degenerative osteoarthritis were requested to remain non-weight bearing for two to three months. Many patients had discontinued crutches prior to the first follow-up visit which was generally two weeks post-operatively. Subsequent visits were scheduled generally at six weeks, twelve weeks, six months, one year, and two years. These follow-up visits were scheduled regardless of the post-operative course. If the patient was having a difficult time post-operatively, then more frequent follow-up visits were arranged. At routine follow-up, range of motion and stability were checked, subjective questioning regarding swelling, pain, giving away, and locking, and comments about any limitations were recorded.

Post-operative results were evaluated generally in the manner similar to that prescribed by Tapper in 1969.[13] This is as follows:

1. Excellent; The patient had no symptoms and no disability related to his knee.
2. Good: Patient had minimal symptoms such as aching or weakness after heavy use or effusion after heavy exertion, but there was essentially no disability.
3. Fair: Patient had symptoms such as trouble kneeling or climbing stairs, weakness or pain or discomfort had become enough of a problem to interfere somewhat with everyday activities and the patient thought he had some disability. He is active but could not participate in vigorous sports such as skiing, tennis, football, etc.
4. Poor: Symptoms were severe, including all those listed under number three as well as the presence of pain at rest, limited to motion and locking. The patient was clearly disabled and his ac-

tivities, including walking, were definitely limited because of his knee.

The results were analyzed according to separate pathology. In many cases, multiple problems were treated, and the groupings were arranged in such a way as to keep the problems of similar prognosis together; for example: an arthroscopic surgery which included meniscus pathology would be expected to do better than a meniscus tear with obvious ligamentous instability also present.

The population in this study is geographically stable, coming from a mixed agricultural and industrial area, within a range of 50 miles, which included cities of under 100,000 people. Two year follow-up visits are presently being made, those who have failed to make thier one and two year visits as scheduled have been contacted by phone in an attempt to have them return to the office for an examination; where this attempt failed, information was obtained by questioning on the phone.

RESULTS

There were 301 knees operated, including 11 bilateral arthroscopies, six operated twice, and three knees operated three times each. Those patients who had only undergone arthroscopies without surgical intervention, and those who had undergone arthroscopies with the surgery performed via an arthrotomy are excluded. There were 178 cases remaining for study.

Table 1

RESULTS: 301 ARTHROSCOPIES

11	bilateral
6	same knee X 2
3	same knee X 3
123	excluded as not arthroscopic surgeries
178	total in study

Table 2

	PER CENT OF 178
18 shaving chondral surfaces	(10.1%)
23 shaving w/lateral release	(12.9%)
37 synovial plica	(20.8%)
10 loose bodies	(5.6%)
70 meniscectomy	(39.3%)
7 chondroplasty	(3.9%)
13 multiple procedures	(7.3%)
	(99.9%)

These are grouped as follows:

1. Eighteen arthroscopies with shaving of the patella or condylar surfaces;
2. Twenty-three arthroscopies with shaving of the patella or condylar surfaces with lateral release of the retinaculum to correct patello-femoral dysfunction;
3. Thirty-seven arthroscopies with excision of synovial plica;
4. Ten arthroscopies with removal of loose bodies; (More loose bodies were removed, but only incidentally to other procedures and those cases were included elsewhere.);
5. Seventy arthroscopies with medial or lateral meniscectomies; (Both partial and total meniscectomies were included together.);
6. Seven arthroscopies with chondroplasties of the patellar condylar surfaces; (This is a deep burring operation in which the surface of the bone is abraded down to interchondral bone.);
7. Thirteen cases with multiple procedures done in greater than two major areas of pathology in the same knee treated under arthroscopic control; (For example, a torn meniscus with degenerative osteoarthritis and fibrotic synovial plica or patello-femoral dysfunction requiring a meniscectomy with excision of the plica, lateral release, and chondroplasty.)

The time span between the first visit and surgery ranged from 36.6 days for patients with meniscus disease to

135.5 days for patients with synovial plica disease. Those patients who eventually were provided with lateral releases or chondral shaving tended to be treated prior to their surgical intervention for longer periods of time than those with meniscus disease. The visits prior to surgery were also more numerous, with over three pre-surgical office visits for patients with synovial plica disease. The time prior to surgery averaged four to five months.

Due to the variety of problems treated with arthroscopic surgery, patients of similar pathology were grouped together in evaluating pre-operative care and post-operative results. Return to normal activity was recorded; without attempting to record specific functions, keeping in mind that the normal demand that an individual placed on the knee is extremely variable and only the return to the individual patient's level of "normalcy" has been evaluated.

Table 3

CHONDRAL SHAVING	
Number of Patients	18
Average Age	36.2
Visits Before Surgery	1.6
Return to Normal Activities	5.6 wks
Days Prior to Surgery	80.5

RESULTS 94.5%			
Excellent 1, (5.6%)	Good 13, (72.2%)	Fair 2, (11.1%)	Poor 1 (5.6%)

CHONDRAL SHAVING

The 18 patients who underwent shaving of the patella of chondral surfaces ranges from 15 to 66 years of age, averaging 36.2 years. (Table 3) There were eight females and ten males. Bilateral arthroscopies were done on one male and one female. The average time from the first visit to surgery was 80.49 days. Return to work or normal activities averaged 5.6 weeks. The results were generally good; one patient can be considered excellent in that he is a competition weight lifter and has since returned to competitive weight lifting without the recurrence of pain. The results in two patients have been considered only fair, both of whom have had relatively severe degenerative osteoarthritis. One of these is the oldest in the group, a lady, suffering from the sequella of polio, with marked deformities of her ankles and feet and a marked genu valgus. She had previously undergone high tibial osteotomy to correct the valgus and continues to wear a Lenox-Hill brace in order to assist her in avoiding progression of her valgus deformity while she ambulates using Canadian crutches. She rides a stationary bicycle and walks in the woods using the crutches and feels that she has improved in comparison to her pre-operative situation. One patient with marked patello-femoral arthritis has done poorly, continuing to be significantly debilitated, ambulating without crutches but with a straight leg and a persistent effusion. He had not improved since surgery, nor has the surgery made him worse than his pre-operative condition.

Table 4

LATERAL RELEASE	
Number of Patients	23
Average Age	28.8
Visits Before Surgery	2.4
Return to Normal Activities	8.3 wks
Days Prior to Surgery	54.9

RESULTS 108.7%			
Excellent 3, (13%)	Good 16, (69.4%)	Fair 4, (17.4%)	Poor 2 (8.7%)

LATERAL RELEASE

There were 23 patients who underwent lateral release with incidental shaving of the patella. (Table 4) The average age was 28.8 years ranging from 12 to 51 years of age. They averaged 2.4 visits prior to surgery. The time from the first office visit to surgery was 54.9 days. Return to nor-

mal activities averaged 8.3 weeks. There were 13 males and ten females, with three females undergoing bilateral surgery. Following this surgery, the patients are generally debilitated for approximately six weeks due a persistent effusion. Ambulation is allowed as soon as the patient can do so without pain eliminating the crutches when they can walk pain free. This generally occurs within the first two weeks postoperatively. Of the 25 knees operated, 16 had good results and three excellent, four only fair and two had poor results.

The two patients with poor results were male, one of whom was seen for the first time after ten months of being on crutches following a Workers' Compensation injury. Though he is now ambulating, he continues to be significantly disabled due to his knee, which shows no sign of swelling or instability, but continues to give him significant pain. The other patient has marked degeneration in his infrapatellar surface with a grooving of the patella, as it apparently had previously dislocated on several occasions. This patient has since undergone quadricepsplasty and continues to have pain in the knee, though he functions at his job as a gas station attendant. Of the patients with only fair results, two had undergone bilateral surgery with the continuing disability of intermittent pain. A 26 year old female with bilateral lateral sitting patellas and marked chondromalacia of her patellas has had a good result in one knee, the opposite knee persists in causing her discomfort. A 22 year old female, who had undergone bilateral arthroscopies with lateral releases on two separate occasions, is considered fair since she continues to have pain at the superior pole of her patellas. The pain is intermittent and seems to be related to changes in the weather and her quadriceps tone has remained poor. Walking is not painful, but deep knee bends required to do general office work and filing will cause her pain. A 51 year old woman, who is less than five feet tall and weighs approximately 200 pounds, was operated after consultation in the hospital when she was admitted for severe pain and locking in her knee. She had degenerative arthritis of the medial femoral condyle and lateral femoral condyle with a lateral sitting patella. Post-operatively, her pain relief was quite dramatic. She continues to do better than she had been pre-operatively, but she continues to experience the symptoms described in the fair category.

Table 5

SYNOVIAL PLICA	
Number of Patients	29
Average Age	26.4
Visits Before Surgery	3.09
Return to Normal Activities	6 wks
Days Prior to Surgery	130

RESULTS 100%			
Excellent 2, (6.9%)	Good 22, (75.9%)	Fair 4, (13.8%)	Poor 1 (3.4%)

SYNOVIAL PLICA

Synovial plicae were excised from 34 knees in 29 patients ranging in ages from 15 to 56. (Table 5) These patients averaged 3.09 visits prior to surgery with 130 days between the first visit and the operative procedure. They required six weeks to return to normal activities. Only two patients can be considered good results and four continue to be considered fair. All four of these patients, two female and two male, have had other procedures done on their knees: one patient has undergone an open procedure; the other three have had repeat arthroscopies without significant relief of their symptomatology. The poor result is a male who had previously undergone a medial meniscectomy with persistent medial joint pain. An arthroscopy revealed a synovial plica which was excised. Following surgery he was doing quite well initially; however, his pain eventually recurred. He developed atrophy in his leg and a

diagnosis of Sudeck's atrophy has been suggested.

Table 6

LOOSE BODIES	
Number of Patients	10
Average Age	38.6
Visits Before Surgery	2.1
Return to Normal Activities	9 wks
Days Prior to Surgery	46

RESULTS 100%		
Excellent 3, (30%)	Good 6, (60%)	Fair 1 (10%)

LOOSE BODIES

Ten patients underwent arthroscopic surgery primarily to remove loose bodies, without additional significant surgery. (Table 6) They averaged 38.6 years of age, ranging from 14 years of age to 75. An average of 46 days passed from the first visit to the date of surgery. They were seen on an average of 2.1 visits prior to surgery. There were three patients with excellent results, two of them under 30 years of age with no significant disease other than the loose bodies. There was a 51 year old female with locking in the posterior medial aspect of the knee, due to the loose body which had been present for approximately ten years. The patient avoided surgery due to fear of having a stiff leg post-operatively. This patient had significant degenerative changes within the knee and, in the future, can be expected to develop symptoms.

Six patients had good results, one of which was a 75 year old woman who developed locking of her knee due to a loose body. This locking was in the most functional knee, since the opposite knee was severely degenerative to the extent that she could not bear weight on it without assistance. She subsequently underwent a total knee replacement in the opposite knee. She has done quite well bearing her weight on the knee from which the loose body has been removed, though she also suffers from significant degenerative changes in that knee and will eventually require further surgery. One patient can be considered to have a fair result, with multiple loose bodies removed from her knee. This 26 year old female showed an extensive amount of degenerative change within her knee, having had multiple surgeries previously for patello-femoral problems, as well as for meniscus disease.

Table 7

MENISCECTOMY	
Number of Patients	70
Average Age	34
Visits Before Surgery	1.4
Return to Normal Activities	15.5 wks
Days Prior to Surgery	36

RESULTS 100%			
Excellent 14, (20%)	Good 40, (57.1%)	Fair 14, (20%)	Poor 2 (2.9%)

MENISCECTOMY

There were 70 patients who had undergone meniscectomy as the primary surgery done under arthroscopic control. (Table 7) They averaged 1.4 visits prior to surgery and 36 days from the first visit to the operation. They returned to normal activities 15.5 weeks after surgery. The average age was 34 years and the ages ranged from 11 to 78 years of age. Nineteen patients were females, the remainder were males. There were 14 excellent results, 40 good results, 14 fair, and two poor. There did not seem to be any relationship between age and excellent results. The patients who were considered only fair had either significant ligamentous instability or degenerative arthritis, except for one patient who presented with a classic torn medial meniscus which was arthroscopically excised, and since the surgery has displayed symptoms of synovial plica pathology. This patient had a history of direct trauma to the knee over one

year prior to the surgery, with a subsequent injury which resulted in the torn meniscus. There were two patients for whom the meniscectomy was not helpful. In both cases the patients had significant degenerative disease of the knees; both were 57 year old females. One patient had rheumatoid arthritis with previous Austin-Moore prosthesis in the operative hip and peripheral vascular disease. The other patient had extensive degenerative arthritis. She is obese and has had what seems to be increased symptomatology with increased medial joint pain since her surgery in July, 1980.

Table 8

CHONDROPLASTY	
Number of Patients	7
Average Age	50.5
Visits Before Surgery	1
Return to Normal Activities	2.5 mo.
Days Prior to Surgery	10
RESULTS 100%	
Good 6	

CHONDROPLASTY

The chondroplasty procedure, using the high speed burr instrument to abrade the degenerative surface down to interchondral bone, is a relatively new procedure, with only a small volume to present in this study. (Table 8) There are seven patients involved, averaging one visit prior to surgery, with surgery scheduled ten days after the first visit. These patients returned to normal activities at approximately two and a half months after surgery.

At this point, the criteria used in evaluating the results must be altered from those used in the other groups. These patients suffer from degenerative arthritis and have been relatively disabled for an extended period of time. The ages ranged from 33 to 70 years. There were four women and four men involved. The results are considered good if the patient is doing better than he was prior to surgery; fair if the pain is the same as prior to the surgery; and poor if there has been a negative effect in having the surgery performed. There were no patients that would be considered excellent, since all of them continued to have symptoms with regard to their arthritis following surgery. Of the seven patients who have undergone this procedure, one has been lost to follow-up. Six have good results and have improved since their surgery. The eldest, a 70 year old man, can ride a stationary bicycle without any pain. Pre-operatively he was experiencing pain at night; relief was noted within the first few days post-operatively, and the night pain has not recurred. He continues to have pain in the medial joint of his knee when he attempts to walk for greater than one half mile. He is an avid walker and this continues to disappoint him.

Table 9

MULTIPLE PROCEDURES		
Number of Patients		13
Average Age		37.5
Visits Before Surgery		3.8
Return to Normal Activities		——
Days Prior to Surgery		112.9
RESULTS 100%		
Good 8, (61.5%)	Fair 4, (30.8%)	Poor 1 (7.7%)

MULTIPLE PROCEDURES

A number of patients resubmitted to arthroscopy and, on occasion, arthrotomy. (Table 9) there were ten such patients; they averaged 3.8 visits prior to surgery and 112.9 days from the first visit to the date of the first surgery. Statistics for returning to normal activities are not significant, in that the patients having undergone multiple procedures, had been returned to activities, and then discontinued them for a second procedure. There were three patients who had multiple procedures done during one arthroscopic surgery.

They returned to normal activities at eight weeks, 14 weeks, and 18 weeks. All three of the patients were markedly obese, all well over 200 pounds. One patient has begun to lose weight and her result has been good. One of the others also has had good results. The third, who returned to work at 19 weeks, continues to be considered only fair; her procedure included removal of torn portions of the posterior cruciate, excision of a supra-patellar plica, chondroplasty of the medial femoral condyle, and partial medial meniscectomy. The other seven included in this classification have undergone multiple procedures for ligamentous instability, as well as cartilagenous lesions, progressing over a period of one to two years. Using the Lenox-Hill bracing and exercise programs the results have been favorable considering the disease.

The other two patients with only fair results include an 18 year old female who initially underwent an arthrotomy with repair of her posterior horn of the medial meniscus; subsequent to that, the meniscus was excised with a repeat arthrotomy. Approximately one year after that procedure, she underwent an arthroscopic examination which showed no added pathology in the meniscus, with the anterior horn still intact and apparently stable. Her entire knee showed degenerative changes generalized throughout the knee, with multiple minute loose bodies, but with no evidence to explain the pathology. This patient continues to have parapatellar pain. The other patient with a fair result, a 50 year old female, underwent an arthroscopy with intra-articular shaving of the medial and lateral femoral condyles, partial excision of the lateral meniscus, shaving of the infra-patellar surface, and lateral release of the right knee. She is obese and has had some improvement with regard to her knee. She continues to be unable to work due to pain in her knee.

DISCUSSION

The data obtained in this study of two years cannot be adequately compared with other studies which involve five and ten year follow-up. Also, the procedures such as synovial plica excision and burr chondroplasty are rather distinct as predominantly arthroscopic procedures, and cannot, therefore, be easily compared to surgeries done via an arthrotomy incision.

In the area of patello-femoral dysfunctions, the results of the study show that isolated chondromalacia of the patella was not a common finding in this population. The results of shaving of the patella have been satisfactory, but the complaint, without added pathology, is not found as often as perhaps might have been expected.

The results of shaving of the patella associated with a lateral release due to lateral sitting patella have been most interesting. Not only is a lateral release helpful in the treatment of chronic subluxation of the patella, but the diagnosis of lateral sitting or excessive lateral pressure syndrome, as described by Ficat, is made clear with the use of the arthroscope. X-ray evaluations of the patello-femoral relationship continue to evade reliable reproduction in spite of intricate descriptions. It seems as though accurate angular radiographs of the patello-femoral joint should be as helpful as arthrograms are in the tibial-femoral joint. A good arthrogram requires a radiographer who is most interested in the problem and is willing to devote the time to obtain accurate reproducible films obtained by patient specific positioning and the development of individual techniques by each radiology department.[14] The arthroscopic view gives a direct visualization rather than only an outline of the physical situation. During an arthroscopy the knee is distended and the muscle tone is absent due to anesthesia. This definitely alters the functional anatomy and the arthroscopist cannot assume that he is visualizing normal physiology without alteration.

Often patello-femoral problems are relieved by decreased activity. Open surgery for such a problem, especially if it becomes asymptomatic with de-

creased activity, is difficult to justify. Conversely, the athlete who wishes to continue to remain healthy and active finds it difficult to accept a sedentary lifestyle due to patello-femoral pain. Conservative measures with first a period of rest and then appropriate exercise and knee bracing, of course, should be attempted. Should this fail, and signs of structural abnormality such as genu valgus and lateral and medial persistent parapatellar pain exist with recurrent symptoms on increasing activity, then it is reasonable, even in the face of negative x-rays, to undergo arthroscopy and visualize the actual tracking of the patella in flexion and extension. If on flexion of the knee to 90°, the medial facet of the patella fails to touch the medial femoral condyle, even with direct pressure applied to the patella with the palm of the hand, an arthroscopic lateral release is a reasonable procedure in a patient that has failed with conservative therapy. In this series the patients have been advised that should a lateral release be necessary they could expect six weeks of swelling about the knee, although they would be able to ambulate without the use of crutches as soon as they could do so without pain. This is commonly within the first one to two weeks post-operatively.

There is one patient in this series who underwent lateral release at the age of 66. Under arthroscopic observation it was noted that the endochondral bone was visualized on the lateral facet of the patella and on the lateral femoral condyle at the points of articulation. The medial facet of the patella did indeed touch the medial femoral condyle when the knee was flexed to 90°. The medial side also showed minimal degenerative changes. This situation seems to indicate that the patient had experienced lateral pressure syndrome throughout most of her life, tolerating her intermittent discomfort until the last three years, when she had to significantly curtail her activities due to the nearly constant discomfort, including discomfort at rest.

In the situations regarding chronic subluxuation of the patella in the young adolescent, lateral release under arthroscopic control with shaving of the patella surface, was most commonly done with a second procedure at a later date in order to advance the vastus medialis and/or translocate the patellar tendon, if the lateral release had not been successful in eliminating the subluxation. The lateral release alone seems to have been successful enough to continue its use in view of the decreased morbidity and elimination of cosmetic problems with large incisional scars about the knee. The future use of the arthroscope in percutaneous imbrication of the medial retinaculum may prove to be a more definitive procedure in such cases wherein it is felt that the lateral release alone is not going to be sufficient.

Lateral releases have been done as a blind procedure with success by many surgeons. One such attempt was done in this series using a small puncture wound in the superior lateral aspect of the suprapatellar pouch utilizing the meniscitome. When this was done and the procedure seemed to be complete, the arthroscope was placed in the suprapatellar pouch medially; although a significant bulging of distended fluid was noted in the lateral subcutaneous tissue along the retinacular incision, a few areas of retinaculum were still intact. The distending saline extravacated along the path of the meniscitome without actually appropriately being associated with the retinacular release. This, of course, remains a viable procedure providing the surgeon assures himself of the retinacular release by testing the laxity of the retinaculum. This is done by turning the patella on end or 90° to the horizontal.

One of the greatest advantages of arthroscopic surgery is in the ability to diagnose secondary problems during a routine pre-surgical arthroscopy.[14] For example, a patient with a lateral sitting patella may also have a significant synovial plica impinging upon the medial aspect of the knee, thus giving

reasonable evidence for the pre-operative confusion as to the appropriate diagnosis, since the patient's pain seems to vary from one office visit to the next. Separate undiagnosed pathology can also be the cause of continued symptomatology, in spite of the fact that the patient has had a definitive therapy for a problem that was well defined at the time of surgery; (i.e., associated meniscial lesions are also found incidentally to the lesion most suspected, and with the arthroscope diagnosing these associated lesions, the patient can possible be saved a second procedure by having all appropriate procedures done at one time.[15])

The synovial plica has been noted to be a pathological structure only in recent history.[7] The structures are found in the general population and have not been found to be pathological merely by being present in the knee. Preoperative evaluation with adequate history and physical examination concerning the specific problems is probably at no time more important than in attempting to diagnose the extent of pathology brought on by a synovial plica. If the patient has been treated with conservative care, seen over a period of several months, and continues to experience discomfort in the area wherein the plica is found, then it seems reasonable that on arthroscopy, if the plica is indeed seen to touch the medial femoral condyle in flexion, and if there is no other associated pathology in the general area, then the plica can be removed, even if the degenerative changes have not occurred.

This is the approach in this series and the results have been gratifying. From the statistics it has been seen that the patients average 3.9 visits and approximately four months spent preoperatively in an attempt to relieve their discomfort conservatively. On arthroscopy, the surgical treatment was one of excision of a synovial plica and the post-operative results show 22 with good results and two with excellent. It may be said that these are patients who may have improved in time without surgical intervention, or conversely, who may have, in the past, submitted to meniscectomies due to their persistent medial joint pain. It might be noted that in this series there were 70 meniscectomies and 29 synovial plica excisions. Keeping in mind that preoperative care was extended over a period of time, it is reasonable to assume that some of these patients who have undergone plica excisions may well have eventually been included in a meniscectomy study.

The approach to plica excision in this series and the results have been gratifying, especially in the treatment of the female adolescent patient. Considerable information has been written concerning the difficulty in diagnosing knee problems in such patients including warnings about performing meniscectomy.[7] Even arthroscopists feel that the diagnostic procedure is not warranted in these patients.[12] The reason for not pursuing these problems in the adolescent female is often the statement that symptoms usually subside eventually without treatment.

This may be the case. However, suppose a young lady is told, by several doctors, that she has nothing wrong with her knee. Realizing she can relieve her discomfort by decreasing her activities and avoiding certain positions of her knee, she does so. It therefore seems reasonable that after a period of time she would improve, avoid her pain, and stop complaining, which produces only ridicule and doubt.

The findings in this series, though admittedly lacking in large numbers, seem to allow at least the hypothesis that the impingement of synovial plica upon the medial femoral condyle could be the pathology causing much of the adolescent female pain on the medial side of the knee, mimicking meniscus tears that are not found on arthrotomy. A suggestion may be offered that due to the fact that females are not trained as boys often are from infancy, to ignore the natural physiological sensitivity to injury, (called pain), they are made acutely sensitive to the problems within the knee and will stop doing

what causes the discomfort and therefore will not develop the erosive phenomenon that occurs with constant irritaiton. Most orthopedists have seen that the younger a child is, the more easily he is adapted to whatever appliance may be applied to him. Therefore, after removing a walking cast, a child will continue to walk as if he wears the cast. Assuming there is an internal pathology and the patient can alter his activities to alleviate the pain, it is quite possible that the patient will develop a habit which will avoid discomfort. It if it is not a grossly abnormal habit, it may go unnoticed, and eventually the patient himself will not recognize the problem. One such patient in this series, a 14 year old male, was unable to run. X-rays were negative, as was the physical examination. The patient refused to admit he was experiencing any pain, though he very obviously ran with a painful gait, avoiding weight bearing on the bent knee. On arthroscopy he had a large transverse band across his suprapatellar pouch, which on flexion, came down upon both the medial and lateral femoral condyles, just proximal to the articulation of the patella. Removal of this band allowed the patient to begin to run without the abnormal gait.

An adult in this series, another male, had undergone three arthroscopies over two years, in a persistent attempt to find the cause of his continued discomfort. (For statistical purposes, this patient was counted only once.) The repeated arthroscopies were done due to a sense of reliability of the patient, since he indeed could be depended upon to provide appropriate information in regard to the symptoms. He had been sent to a rheumatologist and had subsequently been given the diagnosis of osteoarthritis, though x-ray evidence of such changes had not been present. The patient returned after several months of treatment by the rheumatologist, requested further examination, stating that he felt there was something in his knee that was definitely causing problems. In view of the continuing information being disseminated concerning arthroscopic pathology and the possibility that something had been missed on previous evaluations, the procedure was repeated and it was found that the patient had a complete partition of his suprapatellar pouch by a transverse plica. The patient is fairly large, approximately six foot, four inches tall and 250 pounds. The suprapatellar pouch appeared unusually small on retracting the scope during the suprapatellar puncture the scope was found to pass through an opening and into a second chamber of the pouch. This was entirely excised and the patient quite quickly improved in his range of motion and was noted sitting with his knee flexed under his opposite leg, a position he had never been observed to assume previously. He has had a previously diagnosed meniscotibial ligament tear due to an injury; because the partition had been missed previously on arthroscopy, the patient continued to have symptoms that were disabling. He is presently doing quite well, though he intermittently, rather than constantly, has medial joint line tenderness on excessive twisting.

Five adolescent females have undergone synovial plica excision; one of these has had what is considered a fair result due to continued symptoms. It may be reasonable to continue the warnings against operations on adolescent females, but four good results out of five are favorable. Of course a much larger volume of such results are necessary to reasonably challenge accepted ideas formulated by the orthopedists foremost in knee surgery for decades.

LOOSE BODIES

Patients with isolated problems with loose bodies tend to do quite well postoperatively. The problem that caused the loose body may, in the future, add to degenerative changes and the patient can be expected to seek further care. Of the ten patients that seemed to have isolated loose body disease, three had excellent results and returned to their normal activities without

symptomatology. One had ligamentous instability which caused the loose body, resulting in degenerative changes without the knee. The other young man had an acute shearing injury of his medial femoral condyle, when a large cartilagenous fragment was displaced, leaving a fairly large void. No degenerative changes were seen at the time of arthroscopy. A 51 year old female with an excellent result had carried the loose body within her knee for ten years and understandably had considerable degeneration within the knee, though she became asymptomatic post-operatively. As would be expected, the remainder of the patients also had concomitant disease, and long term follow up will likely show that they have had added problems. It is appropriate to note that if there is a loose body, it is quite likely that there is a hole in the bone from which this loose body was produced, and perhaps therapy directed to this area would avoid further degeneration. Therefore, a simple incision over a palpable loose body may not be the complete treatment.

MENISCECTOMY

Meniscectomy is the most often performed procedure under athroscopic control in this study. It is not expected that the long term results from an arthroscopic meniscectomy will be much different than that for an arthrotomy meniscectomy. That is to say, three to six months post-operatively, the signs and symptoms would be expected to be the same, providing the diagnosis was similar in accuracy. The results herein are encouraging, in that, hopefully, the increased diagnostic ability and decreased morbidity expected with arthroscopic surgery, may after long term results are recorded, show that there is an improvement in the results of meniscus surgery. The first arthroscopic meniscectomy (a bucket handle tear) was done on an avid golfer who played and won 18 holes of golf exactly seven days post-operatively. This is not to say that such activity is advisable, but since there is no instability in the retinaculum as created by an arthrotomy incision, the patient is more easily mobilized. Though they seem to recover more quickly, patients generally continue to have an aching sensation and discomfort, and often a moderate effusion for one to two months post-operatively, just as they would with an arthrotomy, indicating (as would be expected) that a major surgery had been done intra-articularly and healing time is needed as would be with an arthrotomy. The advantage with the arthroscope is earlier mobility and peripheral rehabilitation of the leg in general.[16] Return to active participation in sports and/or heavy labor occupations was authorized without restriction, generally at one to three months post-operatively ranging from four days for an anesthesiologist with a bucket handle tear excised ten years after the onset of symptoms, to a 13 year old boy who had a rather significant posterior horn medial meniscus tear, and failed to apropriately rehabilitate his knee. He was returned to active sports after four months. The majority of patients with only meniscus disease or minor ligamentous instability tended to return to work or school gym in three to six weeks.

With regard to additional diagnoses that may be found on arthroscopy with intra-articular meniscectomy, hopefully the correction of these problems at the time of the meniscectomy by making small added incisions in separate areas may have a long term effect in reviewing the results of meniscus surgery; (i.e., if a small loose body is seen in the lateral joint space under arthroscopy, this could easily go undiagnosed through a medial meniscectomy incision and, therefore, remain to cause problems post-operatively.) As mentioned above, a concomitant pathological synovial plica can have the same results. In the case of meniscectomy with additional ligamentous instability which is not significant enough to require reconstruction, convalescence and development of hte muscular supports can be started earlier post-arthroscopic surgery. Also, if the instability is significant enough as to require reconstruction, the

reconstructive surgery can be planned with better assurance and knowledge of the intra-articular pathology after the arthroscopic surgery.

The results of the chondroplasty procedures are not adequate in number or time of follow-up. The early results are encouraging. The post-operative morbidity is minor when compared to high tibial osteotomy or unilateral joint replacement. In this series, the procedure tends to take the place of high tibial osteotomy, a procedure which had met with ambivalent acceptance over the years.[17] The chondroplasties in this study were done initially with aggressive use of mechanical intra-articular cutter; intermittently, the use of the pituitary rongeur or a knife blade were used to assist in debriding loose cartilagenous material from the patella or the femoral condyles. At this time, a high speed burr is being used for such procedures, with reasonable success. The patients with medial joint narrowing due to osteoarthritis, after two and a half to three months non-weight bearing, have been able to return to weight bearing status with less pain than previously. Those that seemed to wish to return to excessive ambulation continue to have discomfort. Most have immediate relief of the discomfort that is felt at rest, especially at night.

CONCLUSION

Arthroscopic surgery is a natural progression from arthroscopic diagnostics. If an instrument can be made to see inside the knee, it seems reasonable that instruments could be made to work inside the knee. There is no question that the arthroscope has improved our ability to diagnose pathology within the knee.[2] The progression to arthroscopic surgery, however, has not yet proven to be of value greater than a surgery done through an arthrotomy. Though it seems that the immediate post-operative morbidity is greater with the arthrotomy, post-healing results three to six months later are probably not significantly different in surgeries such as meniscectomy or lateral release.

Arthroscopic surgery is not only a new method of correcting pathology that has, in previous years, been treated via arthrotomy, but also this method increases the availability of knowledge of diagnoses and theraputics to the extent that pathology previously undiagnosed is found and now treated. Advantages of performing such surgery during one procedure rather than repeating procedures due to continued symptoms is significant and, therefore, warrants dedicated promotion of the technical skills.

The advantages of creating less injury to tissues that previously were normal but necessarily were injured in order to reach the deeper pathology is also of value. At this point the promised advantages are merely promises however, and the results of the procedures must be recorded accurately and compared with the more familiar procedures and diagnostic methods. The most important post-operative result is the satisfaction of the patient and his feeling of improvement. This feeling seems to be cultivated early by their realization that their normal tissues will undergo minimal trauma in having their abnormal tissues treated. A surgeon generally must injure healthy tissue to treat the unhealthy. If we first must do some harm, at least we can endeavor to do less harm.

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Partial Meniscectomy Under Arthroscopic Control

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ABSTRACT: Arthroscopic surgery has made accurate diagnosis possible in over 95% of the cases and has permitted many surgical procedures to be carried out with little morbidity to the patient. A retrospective study of 342 uni-compartmental partial meniscectomies under arthroscopic control reviewing cases performed from January 1, 1980 to December 31, 1980. Surgical techniques as well as surgical instruments are described. The medial meniscus was involved slightly more than twice as often as the lateral meniscus. Involvement of the right and left knees was approximately equal. Transverse tears were seen more often in the younger age group (age 14-22). 52 percent of all displaced longitudinal tears (bucket handle tears) were noted in the 14 to 22 age group. Flap tears were most common (36%) in the 23-35 age group. The most common tear in the female population was the (bucket handle) tear (11 of 44 tears). The average time for an athlete to return to full competition following partial meniscectomy under arthroscopic control ranged from four to six weeks. Most patients required one post operative office visit. Four percent of the total number of cases required a (second look) arthroscopy. Significant symptoms one month post-op included: 1. Pain with crepitance (6%), 2. Persistent effusion (6%), 3. Significant pain (2%), 4. Giving way sensations (1%). The initial results of partial meniscectomy under arthroscopic control appear good, but we will have to wait several more years to know the long term follow-up. **KEY WORDS:** Arthroscope, accurate diagnosis, partial menisectomy, early results good.

INTRODUCTION

Of all the advances in knee surgery over the past decade, arthroscopy with its surgical potentials stands out as one of the greatest achievements. It has made accurate diagnosis possible in over 95% of the cases and has permitted many surgical procedures to be carried out with little morbidity to the patient.[6,7] A conservative philosophy has evolved with emphasis on preserving the meniscus; fewer needless meniscectomies are being done and the evidence suggest that the limited meniscectomy, when possible, is the best for the integrity of the knee joint. Unlike other orthopedic procedures, one usually has to perform several hundred diagnostic arthroscopies before one has enough "experience" to successfully perform partial meniscectomy through the arthroscope.

Arthroscopy had its beginning back in 1918 with a crude looking 7.3 mm diameter cystoscope.[19] Professor Takhei was given credit for the first attempt to visualize the interior of the knee using arthroscopy technique.[19] There were many improvements and modifications from 1918 to 1957, but most agree, "modern arthroscopy" occurred with the development of the #21 arthroscope by Dr. Watanabe, a pupil of Professor Takhei. Dr. Watanabe went on to perform the first partial

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meniscectomy under arthroscopic control in 1962.[5] It was not until the late 1960's that arthroscopy took hold in North America, and then it had a very modest beginning. In the early 1970's most of the emphasis was on the diagnostic capabilities of the arthroscope. Although, in the past four to five years, thanks to the ingenuity and foresight of the late Dr. Richard O'Connor, emphasis has been placed on the arthroscope's usefullness as a surgical as well as diagnostic tool.[12,13]

Skepticism was raised about removing only the torn portion of a meniscus, as previous literature stated that a total or subtotal meniscectomy had to be performed or the patient would continue to have knee problems. Again, thanks to some of the pioneers in this field such as Watanabe, Jackson, McGinty, Joyce, Casscells, O'Connor, and Johnson, the skepticism is being replaced by the realism that removal of only the torn portion of a meniscus can be performed with good initial results. The long term results are not yet in, but good results are being reported in six and seven year follow-up studies.[8,9,10,11,14]

There are many types of arthroscopes now available. They vary in diameter from 1.7 mm to 6.5 mm. There are different angles of view, ranging from the direct viewing arthroscope with a viewing range of 10 degrees, that is 170 to 180 degrees viewing angle, to the angled arthroscopes with viewing angles ranging from 30 to 120 degrees. The 30 degree incline 4 mm arthroscope is probably the one used the majority of time. It gives a viewing range of 30 degrees, from 135 to 165 degree viewing angle, and when you rotate this arthroscope you can see approximately 50% more than with the direct viewing arthroscope. The use of different viewing angles and different diameter arthroscopes, allows the arthroscopist to visualize difficult and remote areas of the joint. In 1976 the operating arthroscope was introduced. This arthroscope had an offset eye piece that allowed the introduction of instruments through the arthroscope under direct control. With the operating arthroscope there is the disadvantage of having to operate with a small lens system because much of the space within the sheath is occupied by a channel for a grasping or cutting tool that is being employed. Also the operating arthroscope is not easily maneuvered about the joint. As a result, many surgeons prefer not to use the operating arthroscope and are now using the three portal technique.

At the present time, surgical techniques are highly individualized and varied from tear to tear. Some of the simpler procedures such as shaving the patella, release of a tight lateral capsule or retinaculum, division of a thickened plica, or removal of a loose body may not require as much surgical skill and experience using the arthroscope, but meniscectomies require a great deal more skill and experience and reports of surgeons working three to four hours to remove a meniscus under arthroscopic control is not uncommon. Even some of the more experienced arthroscopic surgeons occasionally take several hours to perform a difficult meniscectomy. In performing partial meniscectomies under arthroscopic control there are several technical aspects which, if followed, will make the procedure less difficult and hopefully produce better results.

The arthroscopist must have the appropriate instruments and be familiar with them. Currently there are three, four and five millimeter surgical instruments available including various knives, scissors, grasping forceps, cutting forceps, basket forceps and rongeurs. There are also motorized instruments for debriding and trimming portions of the meniscus and other soft tissue structures.

The probe is the most important single instrument you can have. The arthroscope is a monocular system and as such you do not have depth perception, and the probe allows you to measure depth and size of the defect, firmness of the meniscus and check the meniscus for stability. The probe also teaches you to triangulate, which is one

of the things a surgeon must learn if he is to perform surgery under arthroscopic control. This means placing the arthroscope into the joint through one portal and the probe through the other portal and being able to use the instruments through that portal while visualizing through the arthroscope. Using the probe enables you to determine if there has been loss of continuity to portions of the meniscus. Today, we note that a meniscus tear may be described as an incomplete tear or complete tear.[13] We will frequently see an incomplete tear such as along the posterior, inferior or superior surface of the meniscus. The depth and extent of the tear can then be determined by insertion of the probe. An incomplete tear is found to still have numerous fiberous attachments across the rupture. The incomplete ruptured surface separates during complex joint motion when the joint is loaded and this separation may be responsible for clinical complaints of giving way. True locking sensation is always associated with a complete vertical separation, usually originating in the posterior segment of the meniscus. Tears that are incomplete and are not clinically disabling and no evidence of articular cartilage damage may be left alone unless extensive morbidity can be demonstrated at the time of arthroscopy. Recent studies have shown that the weight bearing force carried through the meniscus on the medial side is approximately 50% and on the lateral side 65%.[1,16,17] For this reason tears that are incomplete and are not clinically disabling and no evidence of articular cartilage damage probably should be left alone unless excessive morbidity can be demonstrated at the time of arthroscopy.

A good irrigation system is mandatory. The three liter normal saline bags for constant irrigation of the joint work quite well. These bags should be suspended about one meter above the surgical table for adequate inflow pressure. The inflow irrigation should be open constantly for hydrostatic pressure to be maintained. The inflow cannula should be larger than the out flow opening to maintain the hydrostatic pressure for better visualization. A 4.5 mm cannula and infusion adapter from dyonics works quite well as an inflow cannula. You may place this inflow cannula through the medial or lateral suprapatella portal region. If you drill several additional little holes in the side of the cannula that is intra-articular, this will help maintain a better inflow, especially if you flex the knee, as this has a tendency to block off the end of the cannula, and the holes on the sides will allow continual inflow of the irrigation.

You must be familiar with many portals through which the arthroscope as well as accessory instruments may be introduced. (Fig. #1). The portals most commonly used are: 1) Anterolateral Infrapatellar Portal, 2) Anteromedial Infrapatellar Portal, 3) Posterolateral Portal, 4) Posteromedial Portal, 5) Lateral Suprapatellar Portal, 6) Medial Suprapatellar Portal, 7) Central Patellar Tendon Splitting Portal, 8) Mid-Patellar Lateral Portal, 9) Mid-Patellar Medial Portal. You may choose to use the two portal or three portal approach in performing meniscectomies. When using the two portal approach, you usually

1) Anterolateral infrapatellar, 2) anteromedial infrapatellar, 3) posterolateral, 4) posteromedial, 5) Lateral suprapatellar, 6) medial suprapatellar, 7) central patellar tendon splitting, 8) mid-patellar lateral, 9) mid-patellar.

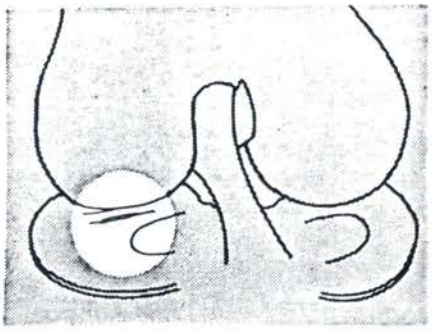
use the operating arthroscope. One of the portals would be used to place tension on the torn portion of the meniscus while the cutting instrument is passed through the operating arthroscope to cut the ends of the torn meniscus. The Swedish method, using a three portal approach, with the arthroscope placed through the patella tendon and a portal anteromedial and anterolateral, made less crowding of the instruments and hence partial meniscectomy less difficult.[3] You may also use the three portal method without going through the patella tendon. Dr. Lenny Johnson popularized this method.[9] Dr. Johnson utilized an anteromedial and anterolateral portal with a third portal placed just medial or lateral to the anteromedial or anterolateral portal. You may choose to use the approach by Dr. Patel, who introduces an angled arthroscope from above passing it through the patellofemoral joint.[15]

A leg holder, around the distal thigh to stabilize the knee is not mandatory, but arthroscopic surgery, especially meniscal surgery is easier using such a device. With a leg holder you can control varus and valgus stress to the knee by placing the leg on you hip while in the sitting position. This gives you exact control of how much stress you want to apply to the leg. By using a stool on coasters you can control flexion and extension as well as valgus and varus stress. The only problem you might run into is controlling extremes of rotation of the tibia, which can be a problem if you have a knee with excessive rotatory instability. You may wish to stand while performing this procedure with the leg on your hip, or you may wish to have an assistant control the stress on the leg. You will just have to try the different techniques and see which one is most comfortable for you.

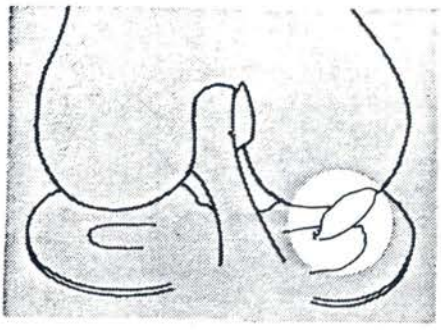
When examining the knee go through the same pattern every time, that way, there is less chance of missing any pathology. If you are unable to see or palpate the posterior one-third of the medial and/or lateral meniscus through the anteromedial and/or anterolateral approach, try placing the arthroscope through the intercondylar notch to visualize the posterior one-third of the meniscus. This can usually be done by flexing and extending the knee with slight rotation on the tibia and slight pressure applied to a blunt trocar placed in the arthroscopic sheath. The 70 degree arthroscope through the intercondylar notch allows excellent visualization at the posterior one-third of the meniscus as well as visualization of the posterior cruciate ligament. If you are unable to get through the intercondylar notch, then use the postero medial or posterolateral approach. For best visualization of the medial meniscus, the knee should be in full extension or perhaps 10 to 20 degree flexion with the tibia in external rotation while applying valgus stress. For best visualization of the lateral meniscus, the knee is again near full extension with varus stress applied, usually with quite a bit of internal rotation.

The use of a 3 1/2 inch 18 guage spinal needle is a good instrument to use to determine the exact placement of your second and third stab incisional area. You can place the spinal needle in the anticipated incisional area and under direct observation with the arthroscope. You can visualize if the tip of the needle is able to reach the desired area that you may wish to place your probe or surgical instrument. If you are unable to palpate the desired area with the spinal needle, then by repositioning the needle you can find the desired position for your stab incision.

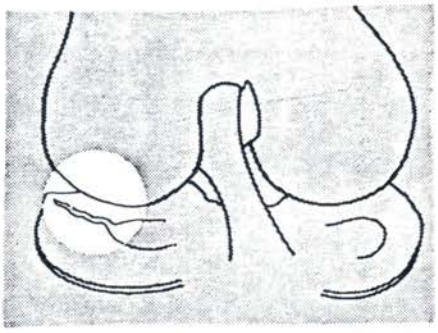
The types of tears I've seen that are amenable to partial meniscectomy performed under arthroscopic control I have classified as follows: 1) Longitudinal tears posterior one-third, 2) flap tears, 3) transverse tears, 4) bucket handle tears, 5) degenerative tears. (Fig. #2) There are other classifications that further subdivide these tears. It is my opinion that there are three basic type of tears; 1) longitudinal tear, 2) transverse tear, 3) interstitial or degenerative tear. I feel that the obli-



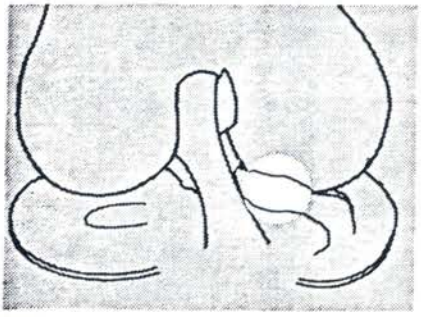
Longitudinal Tear Posterior 1/3



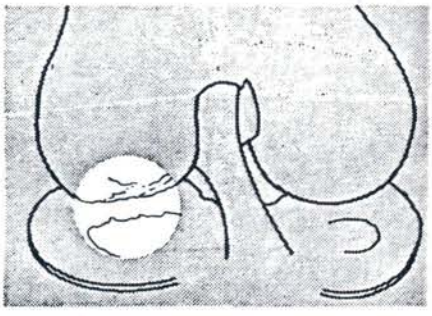
Flap Tear



Transverse Tear



Bucket Handle Tear



Degenerated Tear

que tear in the posterior one-third of the knee is probably an extension of a previous longitudinal tear or transverse tear of the posterior horn. I also feel the horizontal or interstitial tear is the beginning of a degenerative type tear that we see in the knee, and I've elected to group these tears all under one heading of degenerative meniscal lesions. Tears of discoid meniscus as well as tears of the anterior one-third of the meniscus are rarely seen in my experience and as such, were not placed in this classification.

Meniscal tears which are longitudinal in the posterior one-third of the knee are probably the most difficult tear to remove especially in a tight knee. One may use basket forceps to remove the torn portion of the meniscus, but this increases the chance of skuffing the articular cartilage. Probably the best approach at this time is to use the retrograde knife to make a gentle curved incision from the anterior axilla of the tear curving around from the inner border of the meniscus. On the posterior medial corner, the grasping forceps may be inserted and the posterior axilla of the tear cut with the torn portion of the meniscus removed under tension.

When you first look into the joint, the flap tears may not appear prominent as they usually are trapped beneath the meniscus and for varification you will frequently have to use the probe to dislodge the flap portion. Excision of this tear may be done by taking it out in one piece using the basket forceps

or may be done with a retrograde knife. A transverse tear is best removed by saucerizing the tear making sure to saucerize back to the tip of the tear as this has a tendency to spread anteriorly and posteriorly to form the so called "parrot beak" type tear.

The bucket handle tear is probably one of the easiest type of tears to remove under arthroscopic control. One can simply incise the anterior axilla of the torn displaced portion of the meniscus and grasp the anterior portion with grasping forceps and using either the operating arthroscope through which an instrument is passed to cut the posterior axilla of the torn postion of the meniscus or one may use the three portal technique and place a cutting instrument through the third portal excising the posterior axilla of the torn portion of meniscus.

The degenerative tears are usually amendable to either the basket forceps or the motorized meniscal cutter.

Figure 3

PARTIAL MENISCECTOMY UNDER ARTHROSCOPIC CONTROL Jan. 1, 1980 to Dec. 31, 1980

421	partial med &/or lat. meniscectomy
-35	menisoresis & partial meniscectomy
-44	22 pts. with med. & lat. meniscectomy
342	pts. with partial meniscectomy

In all these cases is is important to palpate the meniscus after you have finished your partial meniscectomy to make sure the meniscus is balanced. If the meniscus is not balanced, then the patient may continue to have symptoms of a meniscal tear.

DISCUSSION OF CLINICAL DATA

This study reports a one year analysis of partial meniscectomies under arthroscopic control from January 1, 1980 to December 31, 1980. There is a lot in the literature about the advantages of partial meniscectomy under arthroscopic control but very little in the way of statistics to help try to validate these statements. The cases reported in this year long study will be ones dealing with the primary pathology being meniscal injury. Patients with associated secondary pathology such as chondrosis of the articular cartilage, chondral loose bodies and chondrocalcinosis were included in this study. If there was a significant acute ligamentous injury along with a meniscal tear the case was excluded from this study. A total of 421 partial meniscectomies were performed during this year. (Fig. #3) Thirty-five patients had either ligament damage or associated meniscoresis with their partial meniscectomy and were excluded from this study. Twenty-two patients had medial and lateral meniscal tears and were excluded to allow for a more accurate evaluation. This left a total of 342 unicompartmental meniscal tears. The right and left knees were evenly

Figure 4

PARTIAL MENISCECTOMY

RT. KNEE	
156	— male
16	— female
LT. KNEE	
142	— male
28	— female

divided with the right knee involved 172 times and the left knee 170 times. (Fig. #4). Medial meniscal tears were slightly more than twice as common as the lateral meniscal tears. The 22 patients, not included in this study, with tears of both the medial and lateral meniscus represented 6% of the meniscal tears. 117 injuries occurred in recreational activities, 92 in interscholastic activities, 119 were accidental or of inknown origin and 14 were industrial injuries. (Fig. #5).

We tried to see if there was any correlation between the patients age and the type of meniscal tear. (Fig. #6). Patients ages were divided into four groups. The first group, age 14 to 22,

was selected as this was a group of predominantly interscholastic and intercollegiate athletes and felt to be the most active group, probably the most

Figure 5

ACTIVITY AT TIME OF INJURY

Recreational	m	101
Sports	f	16
Interscholastic	m	82
Sports	f	10
Accidental or	m	101
Unknown	f	18
Industrial	m	14

vulnerable group, especially for the longitudinal tears along the posterior 1 3 of the knee, due to the twisting and shearing type forces involved in athletic activities. I felt the 23 to 35 age group would represent "week-end warrior" type of individual, not as physically in shape as the individual in the 14 to 22 age group and as such, might represent a different type of injury pattern. The third group, age 35 to 50 was selected as this age range was felt to represent a less active age, with the type of activities changing from the more strenuous competitive atmosphere to the more pleasure type of sports, such as running, golf and swimming. The 50 and over age group was selected as it was felt this age range would represent the individuals least likely to maintain physical fitness and be more vulnerable to the degenerative type meniscal injuries. As you can see from the graph (Fig. #6), there was no significant higher instance of longitudinal posterior tears in the 14 to 22 age group versus the 23 to 35, or 35 to 50 age group. There was a statistically higher number of lateral transverse tears (22 of 46 or 48%) in the 14 to 22 age group. When this was correlated with the type of sport the athlete was participating in at the time of injury, the majority of these tears occurred in basketball and football (Fig. #7). One might theorize this resulted from the compressive forces of the lateral femoral condyle on the tibial plateau, splitting the meniscus as could occur from a blow to the lateral side of the knee from playing football or in basketball when coming down from a rebound with more force toward the lateral side of the knee. The bucket handle tears occurred most commonly in the 14 to 22 age group with 52% of all bucket handle tears. Of the remaining 48% of bucket handle tears, 36% were seen in the 23 to 35 age group. Thus, in this study, 88% of the bucket handle tears occurred in individuals 14 to 35 years of age. The only significant difference in the type of meniscal tears in the 23 to 35 age group was the flap tear. 36% of all tears in this age group involved flap tears with about equal involvement of the medial and lateral meniscus. The 35 to 50 age group revealed a fairly even distribution of tears. There was a higher number of degenerated medial meniscal tears in this age group than one would normally anticipate, with 30% of the tears, degenerated type tears of the meniscus. The tears noted in the 50 and over age group were distributed fairly evenly as one might expect. The type of tears seen most frequently in the female population was the medial bucket handle tear with ten of the forty-four meniscal tears. Again, the bucket handle tear in the female population was noted most often in the 14 to 22 age group.

The number of tears according to age group were fairly evenly divided among the first three age groups. (Fig. #6). The tear most commonly involved at least in this study, was the longitudinal posterior one-third representing 31% of all cases, with the medial side involved in 19% of the cases and the lateral side in 12% of the cases.

Basketball and football were the two sports producing the greatest number of meniscal tears. (Fig. #7). There was no statistical significance in regards to one sport having a tendency to produce

Figure 6
AGE DISTRIBUTION / TYPE TEAR

	14-22	23-35	36-50	above 50	Total	(%)
Long. Post. 1/3 Med.	m 18	m 18 f 4	m 16	m 8 f 2	m 60 f 6	19%
Long. Post. 1/3 Lat.	m 18 f 4	m 12 f 2	m 2	m 4	m 36 f 6	12%
Transverse Med.	m 8	m 2		m 4	m 14	4%
Transverse Lat.	m 18 f 4	m 6 f 2	m 16		m 40 f 6	14%
Flap Med.	m 6	m 18	m 16	m 4	m 44	13%
Flap Lat.	m 2	m 12 f 2	m 2	m 2	m 18 f 2	6%
Buckethandle Med.	m 20 f 6	m 16 f 2	m 4 f 2		m 40 f 10	15%
Buckethandle Lat.	m 2				m 2	.5%
Degenerated Med.		m 4	m 22 f 2	m 10 f 8	m 36 f 10	13%
Degenerated Lat.			m 4	m 2 f 2	m 6 f 2	2%
Anteroir 1/3 Med.	m 2				m 2	.5%
Discoid Lateral	f 2				f 2	.5%
Total & %	m 94 (28%)	m 88 (25%)	m 82 (24%)	m 34 (9%)	m 298	
Total & %	f 16 (5%)	f 12 (4%)	f 4 (1%)	f 12 (4%)	f 44	

a certain type tear. 223 of the 342 tears (65%) seen in this study occurred while participating in athletic activities, of which 30% involved tears of the longitudinal posterior one-third, 23% on the medial side and 15% on the lateral side. 19% of the tears that occurred while paticipating in athletic activities involved bucket handle tears of the meniscus. Thus, in this study, 57% of the meniscal tears that occurred while participating in athletic activities involved longitudinal posterior one-third of bucket handle tears. 77% (44 of 54 tears) of the torn degenerative meniscus occurred in nonrelated

Figure 7
SPORT / TYPE TEAR

	Football	Softball	Basketball	Wrestle	Track X-count	Volleyball	Tennis	Baseball	Gymn.	No Sport	Other	Total
Long. Post. 1/3 Med.	12	8	12	8		2				16	8	66
Long. Post. 1/3 Lat.	10		12	4	2	2			2	8	2	44
Transverse Med.	2		2		2	2				4	2	14
Transverse Lat.	10	4	10	2				2		12	6	46
Flap Med.	8	2	4	4			2			20	4	44
Flap Lat.	4	2	2							8	4	20
Buckethandle Med.	8	4	12	4			4	2		9	7	50
Buckethandle Lat.	2											2
Degenerated Med.		2			2					38	4	46
Degenerated Lat.		2	2							4		8
Anteroir 1/3 Med.	1			1								2
Discoid Lateral					1	1						2
Total	55	26	56	23	7	7	6	4	2	119	37	342
%	16%	8%	16%	7%	2%	2%	2%	1.5%	.5%	34%	11%	

athletic activities.

We then tried to see if there was any correlation between the onset of symptoms before surgery and type of meniscal tear. (Fig. #8). There were five time slots arbitrarily picked. The first slot represented individuals having problems for less than one month and the last time slot for individuals having problems greater than five years. I wanted to see if certain types of tears produced greater debilitating type symptoms causing the individual to seek medical attention and subsequent

partial meniscectomy. Also, an attempt was made to correlate the longevity of symptoms of a particular tear with degenerative changes in the joint at the time of the arthroscopy. (Fig. #9). The greatest number of patients (36%) had symptoms one to six months before they decided to have arthroscopic surgery. Interestingly, 26 of the 46 patients (56%) were the degenerated medial meniscal tear had symptoms one to six months before having surgery. Chondrosis of the medial compartment was present 41% of the time in association with degenerative medial meniscal tears. If we assume degenerative changes of the chondral bone takes a period of time to develop,

Figure 8
SYMPTOMS BEFORE SURGERY

	1 mo.	1-6 mos.	7-12 mos.	1-5 yrs.	5 yrs.	Total pts.
Long. Post. 1/3 Med.	m 20	m 8 f 2	m 12 f 4	m 14	m 6	60 6
Long. Post. 1/3 Lat.	m 10	m 8 f 2	m 4	m 12 f 4	m 2	36 6
Transverse Med.	m 6	m 2		m 4	m 2	14
Transverse Lat.	m 10 f 4	m 10 f 2	m 12	m 2	m 6	40 6
Flap Med.	m 2	m 14	m 10	m 8	m 10	44
Flap Lat.	m 2	m 8 f 2	m 4	m 4		18 2
Buckethandle Med.	m 8 f 2	m 20 f 8	m 4	m 6	m 2	40 10
Buckethandle Lat.	m 2					2
Degenerated Med.	m 2	m 22 f 4	m 2	m 6 f 2	m 4 f 4	36 10
Degenerated Lat.		m 4			m 2 f 2	6 2
Anteroir 1/3 Med.		m 2				2
Discoid Lateral		f 2				2
Total & %	m 62 (20%) f 6	m 98 (35%) f 22	m 48 (15%) f 4	m 56 (18%) f 6	m 34 (12%) f 6	298 44

Figure 9
CHONDROMALASIA

	Med. Compartment	Lat. Compartment
Long. Post. 1/3 Med.	17 (25%)	
Long. Post. 1/3 Lat.	3 (11%)	2 (4%)
Transverse Med.	3 (21%)	
Transverse Lat.	4 (8%)	4 (8%)
Flap Med.	12 (27%)	
Flap Lat.	1 (.5%)	5 (20%)
Buckethandle Med.	3 (.6%)	
Buckethandle Lat.		
Degenerated Med.	19 (41%)	
Degenerated Lat.	1 (12%)	4 (50%)
Anteroir 1/3 Med.	1 (50%)	
Discoid Lateral		

** 23% of 342 pts. — chondromalasia

and we correlate this with the relatively short duration of symptoms with the degenerative torn medial meniscus, one questions if the tear of the meniscus causes the degenerative changes of the articular surface, or if the degenerated articular surface produced the meniscal tear. This study revealed the majority of bucket handle tears did not occur as an acute onset. 26 of 52 (54%) individuals with bucket handle tears had symptoms one to six months prior to arthroscopic surgery. 12 of 52 (23%) patients presented as acute onset, that is a locked knee, that at the time of arthroscopic surgery revealed a bucket handle tear of the meniscus.

How soon after partial menisectomy under arthroscopic control can people return to work? There are many articles stating that after partial meniscectomy patients may return to work the following day or within one week. This indeed may be true, but how many are able to resume their normal activities without pain or discomfort? I felt certain occupations required a certain level of stress on the knee. As such, a record was kept for one year in regards to the type of work the individual had to perform and when they were able to return to their usual job without restrictions or limitations. (Fig. #10) Represents the average length of time it took these individuals to return to their normal job without restrictions. The patients jobs were broken into four groups according to the degree of stress on the knee, required by the job. The

Figure 10
RETURN TO WORK TIME
(MEDIAN WKS)

Type of Work	Recreational	Accidental	Industrial
Primarily Sitting	4.13	5.15	0
Standing & Walking	6.02	6.82	11.
Climbing & Light Lifting	7.1	8.86	6.6
Heavy Labor	8.82	13.8	15.

Figure 11
POST-OP / RETURN ORGANIZED SPORTS

	No. of Athletes	Med. No. of Weeks
Football	18	4.28
Softball	8	4.25
Basketball	22	5.63
Wrestling	9	4.11
Track & X-Country	3	5
Volleyball	4	6.25
Tennis	4	3.85
Baseball	3	3.66
Gymnastics	2	6

meniscal tears occurring to the interscholastic or intercollegiate athletics were not included in this group as most of these individuals are students in high school or college. Individuals involved in recreational sports were able to return to work sooner than individuals involved in accidental type injuries. The median time to return to work for individuals sustaining torn meniscus from industrial injury was not statistically valid due to the low number of individuals in this group. There were 263 torn meniscus in which the meniscus was the only pathology, with the median time for return to work 4.84 weeks. As can be seen at least in this study, individuals that have associated pathology such as chondrosis or previous ligamentous injuries to the knee required a longer period of time to return to their job without restrictions.

There were 73 athletes injured during the early part of the respective sporting event, and were able to return to that same event following partial meniscectomy. The median number of weeks for these athletes to return to full competition is seen in (Fig. 11). As you can see, most athletes were able to return to full competition within four to six weeks.

As we know re-check post op visits take up your office time as well as require office help. Thus the fewer post operative office visits, the more time you have to see new patient problems. The average number of post op visits in this study was 1.83 with the majority of patients requiring one post op visit.

We then took a look at the post operative problems or complications. (Fig. #12). Significant crepitance, pain or persistent effusion were considered post operative problems and an effort was made to determine the cause of such problems. Pain with crepitance and persistent effusion headed the list with each representing 6% of the total number of meniscectomies. This was followed by significant persistent pain for greater than one month, noted in 2% of the cases. Giving way sensations

Figure 12

SIGNIFICANT SYMPTOMS
1 MO. POST-OP

1. pain c crepitant sensations	18	6%
2. persistent effusion (c or s pain or crepitus)	18	6%
A) requiring aspiration	4	
3. significant pain	7	2%
4. giving-way sensations	4	1%
5. hypoesthesia at puncture site	1	
6. prepatellar bursitis	1	
7. sepsis (clinical)	1	
(cultured)	0	
8. hemarthrosis (requiring aspiration)	0	
9. joint L.O.M.	0	
10. transient touriquet paresis	0	
11. draining sinus	0	
12. granuloma or local wound mass	0	
13. broken instruments	0	
14. painful scar	0	
15. M.I., P.E., thrombophlebitis	0	

was noted in 1% of the cases. There was one case of prepatella bursitis and one case of hypoesthesia at the puncture site area. There was also one case of suspected sepsis by clinical picture but cultures failed to substantiate this clinical diagnosis. Fourteen cases or 4% of the total number of meniscectomies required a "second look arthroscopy". In the group with persistent crepitance and pain for a greater then one month, only two were noted to have a torn meniscus as their only pathology at the time of the initial meniscectomy. (Fig. #13). The rest of this group had varying levels of chondromalacia, chondrocalcinosis, and anterior cruciate ligament insufficiency. It was felt that this associated pathology noted at the time of their initial meniscectomy was producing their symptomatology and only if the symptoms became significant more severe did we consider the second arthroscopy. They were all treated non-

Figure 13

PRESENT PAIN c CREPITUS

	Age	Tear	Associated Path.	Duration	"2nd Look"
1.	69	D.M.	chondrosis P/M	4 mo.	—
2.	26	LP 1/3 M	ACL insuff.	9 mo.	reconstruction
3.	35	F.M.	chondrocalanosis	6 wks	—
4.	56	D.M.	chondrosis P/M/L	11 mo.	—
5.	33	T.L.	chondrosis P	3 mo.	—
6.	43	D.L.	chondrosis L	9 mo.	—
7.	44	D.M.	chondrosis P/M	4 mo.	—
8.	43	D.M.	chondrosis P/M	4 mo.	—
9.	31	LP 1/3 M	chondrosis P/M	6 mo.	—
10.	17	LP 1/3 M	ACL insuff	3 mo.	—
11.	58	F.L.	chondrosis M	3 mo.	—
12.	42	D.M.	chondrosis M	7 mo.	yes
13.	20	T.L.	?	10 mo.	yes
14.	43	LP 1/3 M	chondrosis P ACL insuff.	3 mo.	—
15.	54	D.L.	chondrosis P/M/L	6 mo.	—
16.	17	LP 1/3 M	?	5 mo.	—
17.	23	LP 1/3 M	chondrosis P	5 mo.	yes
18.	28	T.L.	chondrosis M	12 mo.	yes

Figure 14

ANALYSIS OF 2nd LOOK

12. eburnation chondral bone med. — med. patella plica
13. severe chondromalasia lat. compartment
17. chondromalasia patella — synovitis — fibrotic infrapatellar synovia
18. chondromalasia patella & med. compartment

surgically and responded well except for two individuals as noted in (Fig. #14.) Number thirteen required a second arthroscopy which revealed significant chondromalacia or chondrosis of the lateral compartment which was not noted at the time of the initial meniscectomy. Debridement and restricted motion for two months was required for this individual to become asymptomatic. Patient number eighteen had a transverse tear of the lateral meniscus and chondrosis of the medial compartment at the time of the initial arthroscopy. A second look arthroscopy revealed continued chondrosis of the medial compartment and patella which required debridement.

The group with persistent effusion with or without crepitance and pain revealed several cases with associated pathology at the time of initial arthroscopy. (Fig. #15). There were six caes with no other pathology at the time of initial meniscectomy and thus required a second look. The results of the second look are seen in (Fig. #16). Case number five was a case where enough of the lateral meniscus was not saucerized at the time of initial meniscectomy. Case eight was a case of a loose fragment of a meniscus which evidently was not removed at the time of the initial partial meniscectomy. Case number nine was a case where no further pathology could be found at the time of the second arthroscopy. Case number fifteen was a 26 year old male who decided to ride his bicycle twenty miles on a third day post surgery and developed a quite tense effusion that would not resolve after one month. A second arthroscopy revealed a synovitis that responded to irrigation through the arthroscope and a medrol dospak. Case number seventeen was a 24 year old male that had a longitudinal tear of the posterior 1/3 medial meniscus. One week after surgery he developed a warm painful swollen knee and had a low grade fever. Aspiration revealed a cloudy thick blood tinged fluid. This fluid was cultured feeling it was infectious in origin. The cultures were reported as negative for any bacterial growth. The knee remained hot and painful after ten days even though the culture was negative, a second arthroscopy was performed. The clinical intra-articular picture was that of infection. Again cultures were taken and again the cultures were reported as negative. At the time of the second arthroscopy, the joint was thoroughly flushed with normal saline and the patient started on antibiotic therapy with no further pain or swelling of the knee noted after surgery. Case number eighteen was a case where the meniscus was not properly contoured and resulted in a further tear of the posterior lateral corner of the meniscus.

In the group with intra-articular pain, there were five cases of no associated pathology at the time of initial meniscectomy. (Fig. #17). All of these cases responded to non-surgical treatment except for case number eight. (Fig. #18).

All cases of giving way were associated with anterior cruciate ligamentous insufficiency at the time of initial arthroscopy and all responded satisfactory to an exercise program. (Fig. #19). In this study, 18% of the

Figure 15

PERSISTENT EFFUSION

	Age	Tear	Associated Path.	Duration	"2nd Look"
1.	39	D.M.	chondrosis P/M	6 mo.	—
2.	45	F.L.	?	2 mo.	yes
3.	22	LP 1/3 M	ACL insuff.	6 wk.	—
4.	48	D.M.	chondrosis P	4 mo.	—
5.	21	T.L.	?	9 mo.	yes
6.	34	F.M.	chondrosis M	2 mo.	—
7.	55	D.M.	chondrocalcanosis	4 mo.	—
8.	33	LP 1/3 M	chondrosis M	6 wk.	yes
9.	26	LP 1/3 M	?	5 wk.	yes
10.	44	D.M.	chondrosis P/M	9 mo.	—
11.	34	D.M.	chondrosis P/L	12 mo.	yes
12.	67	D.M.	chondrosis P/M	6 wk.	—
13.	45	D.M.	chondrosis P/M	2 mo.	—
14.	26	LP 1/3 L	chondrosis P/M	6 mo.	yes
15.	26	B.M.	?	2 wk.	yes
16.	53	D.M.	chondrosis P	1 mo.	—
17.	24	LP 1/3 M	?	2 wk.	yes
18.	19	LP 1/3 L	?	3 mo.	yes

Figure 16

ANALYSIS OF 2nd LOOK

2. chondromalasia patella
5. additional rear lat. meniscus
8. loose fragment meniscus
9. no pathology (psychosomatic)?
11. adhesions med. & suprapatellar (pain suprapatellar)
14. sharp posteriolateral meniscal corner (impinging)
15. reactive synovitis (bike 18 miles 3rd POD)
17. clinical & arthroscopic picture of infection (culture negative)
18. fragmentation remaining meniscus

cases, revealed an associated anterior cruciate ligament insufficiency secondary to previous tears of the anterior cruciate ligament.

Of the 4% that required a "second look" arthroscopy only 2% had additional pathology from what was noted at the time of the initial arthroscopy and partial meniscectomy.

Figure 17

INTRA-ARTICULAR PAIN

Age	Tear	Associated Pathology	duration	2nd look
1. 19	LP 1/3 L	?	6 mo.	—
2. 23	F.L.	?	6 wk.	—
3. 62	D.M.	chondrosis P/M	4 mo.	—
4. 54	D.M.	chondrosis P	3 mo.	—
5. 56	D.L.	?	7 wk.	—
6. 54	D.M.	chondrosis P	2 mo.	—
7. 23	LP 1/3 M	?	5 mo.	—
8. 17	LP 1/3 M	?	8 mo.	yes

Figure 18

ANALYSIS OF 2nd LOOK

8. transverse tear lateral meniscus

Figure 19

GIVING-WAY SENSATIONS

Age	Tear	Associated Pathology	Duration	2nd Look
1. 17	B.M.	ACL insuff.	—	—
2. 27	LP 1/3 M	ACL insuff.	—	—
3. 33	F.L.	ACL insuff.	—	—
4. 19	B.M.	ACL insuff.	—	—

The advantage to arthroscopic meniscectomy include a lower morbidity rate, shorter hospitalization, removal of only torn portion of meniscus, absence of any appreciable

scar, and rapid rehabilitation. The disadvantages of arthroscopic control meniscectomy include the time required for expertise, increased likelihood of damage to articular cartilage, and a longer period of anesthesia.

As indicated in this study, the initial results of partial meniscectomy under arthroscopic control appear good. The long term results of partial meniscectomy are not in as yet, so we will have to wait several more years to obtain a ten year follow-up on this type of procedure. One danger inherit to arthroscopic surgery is that in an over emphasis of removing the meniscus we may over look the possibility of suturing the peripheral tears which can and probably should be done more often, especially in the teenage group.[2,4,18]

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Instructional Case
Compartment Syndromes

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ABSTRACT: Compartment syndrome is a condition in which increased pressure within a fascial space compromises the circulation to the contents of that space (i.e., muscles and nerves). Compartment syndromes occur most commonly in the lower leg; the anterior compartment is the one most frequently involved, followed by the lateral, deep posterior, and rarely the superficial posterior compartment. They are caused most commonly by fractures or contusions of the lower leg.

Most patients with compartment syndromes can be diagnosed from clinical symptoms and signs alone. These include: 1. Inappropriate pain. 2. Pain with passive stretching of the involved muscles. 3. Swelling of the involved compartment. 4. Paresis. 5. Paresthesias. 6. Usually intact pulses. In equivocal cases intracompartmental pressure measement is a useful adjunct. There are three commonly used techniques: 1. The injection technique (Whitesides). 2. The wick technique (Mubarak). 3. The continuous infusion technique (Matsen). The standardly accepted indication for fasciotomy is a tissue pressure of 45mmHg. There is significant permanent tissue injury if fasciotomy is not performed within 12 hours after the diagnosis of compartment syndrome has been made. This provides a more objective basis for monitoring equivocal cases of compartment syndrome. In times past the indication for fasciotomy was "when you are thinking about doing a fasciotomy, you should do it".

COMPARTMENT SYNDROME

A compartment syndrome is a condition in which increased pressure within a fascial space compromises the circulation to the contents of that space (i.e., muscles and nerves).

The goals of the physician who is caring for a patient with a compartment syndrome are early diagnosis, prompt decompression, and uncomplicated recovery. Most of these patients can be diagnosed and treated in a straight forward manner. However, these goals may not be realized because the clinical presentation of such a patient may be ambiguous and therefore, the management of the affected compartments may be inadequate.

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The diagnosis of compartment syndrome in recent years has been aided by the advent of techniques for measurements of tissue pressures. This has provided an objective means of evaluating and monitoring the status of a compartment.

Compartment syndromes in the upper and lower extremity will be discussed, but emphasis will be placed on the lower extremity because this condition occurs most commonly in the lower leg. The anterior compartment is most frequently involved — followed by the lateral or peroneal, then the deep posterior compartment and rare-

ly the superficial posterior compartment. Each compartment has a nerve coursing through it which, as we will see later, will aid in the diagnosis.

In a large series of tibial fractures, three percent of these patients developed some toe-clawing, weakness and/or paresthesias in the feet! This fact shows that mild compartment syndromes are fairly frequent and often not recognized.

PATHOPHYSIOLOGY

In compartment syndromes the progressive accumulation of interstitial fluid and blood leads to compartment tamponade. This causes more ischemia to the tissues. If progressive, this cycle has to be broken by fasciotomy. If left untreated, within 3-4 days, the pressure and pain gradually subside, but often the weakness and numbness persist. Within a few weeks permanent contractures develop. Volkmann's contracture is the end-stage of this process to muscles and nerves.

ETIOLOGY:

The causes of compartment syndromes of the leg in order of frequency are:[2]

1. Fractures of tibia and/or fibula.
2. Contusions of soft tissues.
3. Post-ischemic swelling (arterial injuries with subsequent compartment syndromes).
4. Drug overdose (limb compression syndrome).
5. Burns.
6. Bleeding diathesis (anticoagulants, etc.).
7. Miscellaneous (exercise, snake bites, etc.)

Tibial fractures account for more than twice as many compartment syndromes as any other cause. The tibial fracture usually involves the shaft and usually is a closed injury, however, open fractures do not preclude having a compartment syndrome. In children the most common cause for compartment syndrome is poor traction techniques in femur fractures (eg. Bryants traction).[3] Many other bony Orthopedic procedures have been associated with compartment syndromes (ORIF, leg lengthening, Hauser procedure, tibial bone graft, osteotomy, etc.). Therefore, prophylactic fasciotomies should often be considered with these major Orthopedic procedures.

In post-ischemic swelling, there has been vascular occulsion in the femoral or popliteal artery due to laceration, thrombosis, or embolization. After surgical correction of the above condition and circulation restored, the swelling may initiate a compartment syndrome. The 6-8 hours of ischemia (i.e. from onset of ischemic episode to completion of surgery) is the turning point where prophylactic fasciotomies often should be performed because of the chance for compartment syndrome is very high.[4] This is another indication for prophylactic fasciotomy.

Patients who overdose on drugs and unknowingly compress their limbs, also can develop compartment syndromes. Often these patients seek medical attention late in the course of their compartment syndromes, and when hospitalized, frequently have other overriding problems (like respiratory depression and/or renal failure).[5] Because of their obtundation, often these patients can have fasciotomies performed under local anesthesia.

DIAGNOSIS:

Most patients with compartment syndromes can be diagnosed from clinical symptoms and signs alone. These include:

1. Inappropriate pain or pain out of proportion to the clinical situation.
2. Pain with passive stretching of the muscles in the involved compartments; gentle stretching of an ischemic muscle causes pain. This is a good indicator, but does rely on the subjective response of the patient (the reliability of the patient and his threshold for pain). Pain is often difficult to evaluate particularly in children and uncooperative, obtunded, or unreliable patients.
3. Swelling and palpable tenseness over the involved compartment is the earliest physical sign of com-

partment syndrome.[6] These findings are manifestations of increased pressure within the compartment. Even though a great deal of subcutaneous edema may mask the underlying swelling, often you can localize compartment involved by careful palpation.

4. Paresis or muscle weakness is likewise difficult to interpret. Ideally you would like to grade muscle strength of all potentially involved muscles. However, weakness may be due to guarding secondary to pain, ischemia of the muscles, nerve involvement, or all three.
5. Paresthesias-Mubarak feels sensory deficit is the most reliable objective sign-provided patient is alert and cooperative.[7] Two point discrimination or a light touch testing are both more sensitive than the commonly used pin prick testing. Each compartment of the leg has at least one nerve coursing through it, so careful sensory examination of the foot will aid in confirming the compartments involved. With delay in treatment, hypesthesia leads to anesthesia.
6. Peripheral pulses and capillary filling (pinkness) are most often normal in compartment syndromes. If there is a question about the pulse due to swelling, Doppler will be helpful. Remember this compartment syndrome is a small vessel disease and that irreversible tissue damage can occur in the face of palpable pulses.

Patients who are suspected of having a compartment syndrome should be reexamined at frequent intervals and the results of each examination documented carefully. Any circumferential dressing should be released and if these significant signs do not resolve soon, fasciotomy is usually indicated.

TISSUE PRESSURE MEASUREMENT

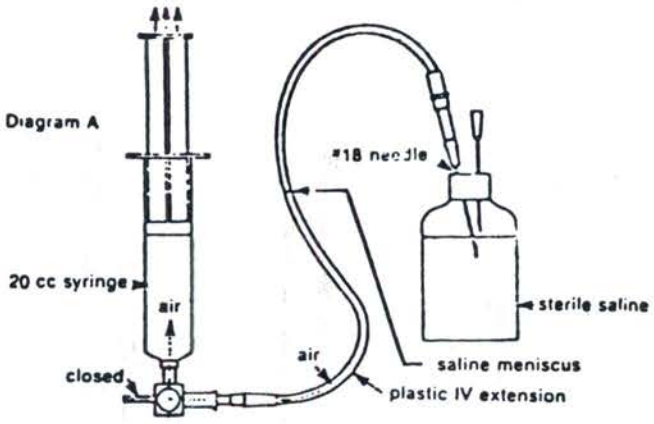
When the diagnosis of compartment syndrome cannot be made or excluded after clinical evaluation, intracompartmental pressure measurement is a useful adjunct. This is especially helpful in equivocal cases or patients who have head injuries, nerve injuries of uncooperative. Three methods of measurement are used: The injection technique, the wick technique, and the infusion technique. Each technique has proven useful in the hands of those familiar with it, but each requires practice before reliable measurement data can be obtained.

1. The injection technique (Fig. 1) was developed and made popular by Thomas Whitesides of Emory University in 1975. It involves a system that includes a 20 cc. glass syringe, I.V. extension tubing, 18 guage needle, mercury manometer, and a four-way stop clock. Sterile saline partially fills one arm of the connecting tubing. The needle is inserted into the muscle compartment (small amount of local anesthetic may be needed). Then pressure is introduced into the system by depressing the syringe. It is slowly increased until the air-fluid level changes or moves. This shows movement of the fluid into the compartment and indicates the pressure within the compartment (red on the manometer).

This technique has the advantage of using in-expensive, readily available equipment, but has a disadvantage that continuous readings cannot be made. This probably is the most commonly used technique in the country.

The following two techniques do have the ability to continuously monitor tissue pressure:

2. The wick technique (Fig. 2) was introduced by Mubarak at the University of California, San Diego.[9] It uses a specially constructed catheter containing fibers protruding from its lumen. The tubing is filled with heparinized saline solution to minimize clotting. The wick increases the surface area in contact with the tissue. To protect its fibers the wick catheter is inserted into the tissues through a larger cannula, which is later withdrawn. The fluid within the tubing is changed to an elec-



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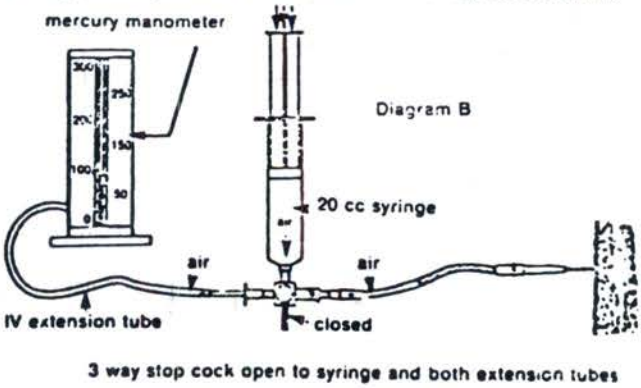

Figure 1.
Whitesides Injection Technique for tissue pressure measurement; upper picture shows aspiration of column of sterile saline into extension tubing: lower picture shows complete system.

trical response and then recorded.

Rorabeck has recently modified this technique using a catheter with slits on the end rather than the wick. This slit catheter technique is more easily manufactured and is currently being distributed by HowMedica Company.

3. The continuous infusion technique (Fig. 3) is advocated by Matsen.[10] The patency of the needle in the tissues is assured by the slow, but continuous infusion of non-heparinized saline solution (0.7 cc. per day).

DEVELOPMENT OF COMPARTMENT SYNDROME

The two most important aspects of the development of compartment syndrome involves the tissue pressure and the length of time from the onset of the symptoms. It is known that muscle can function for three hours until total ischemia, but the nerve is more sensitive to ischemia and ceases functioning after 70-75 minutes (Whitesides).[11]

1. At what tissue pressure is ischemia significant? There is ample evidence that blood flow in arterioles ceases or is ineffective even when tissue pressure is less than diastolic pressure. Whitesides stated that ischemia may begin at tissue pressures which are 10-30 mm.Hg. less than diastolic pressure.[12] For a patient with a blood pressure of 120/80, significant tissue pressure would be 50-70 mm.Hg. This also means that these results should be evaluated in relation to the diastolic pressure of the patient.

Mubarek uses 30 mm.Hg. as an indication for decompressive fasciotomy assuming normal blood pressure.[13]

Matsen uses 45 mm.Hg. as a relative

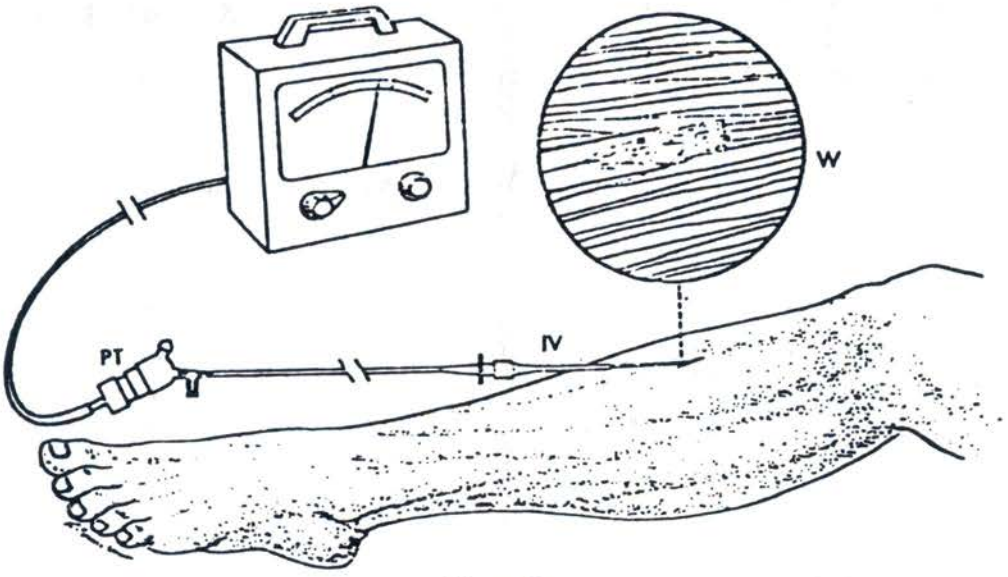

Figure 2.

The wick catheter technique for measuring tissue fluid pressure in compartment syndromes. An intravenous placement unit(IV) aid insertion of sterilized saline-filled catheter. Before insertion wick catheter is connected to pressure transducer(PT) and recorder and calibrated. A close-up view of the catheter tip(W) illustrates how catheter patency and continuous fluid transmission are maintained by numerous wick fibers.

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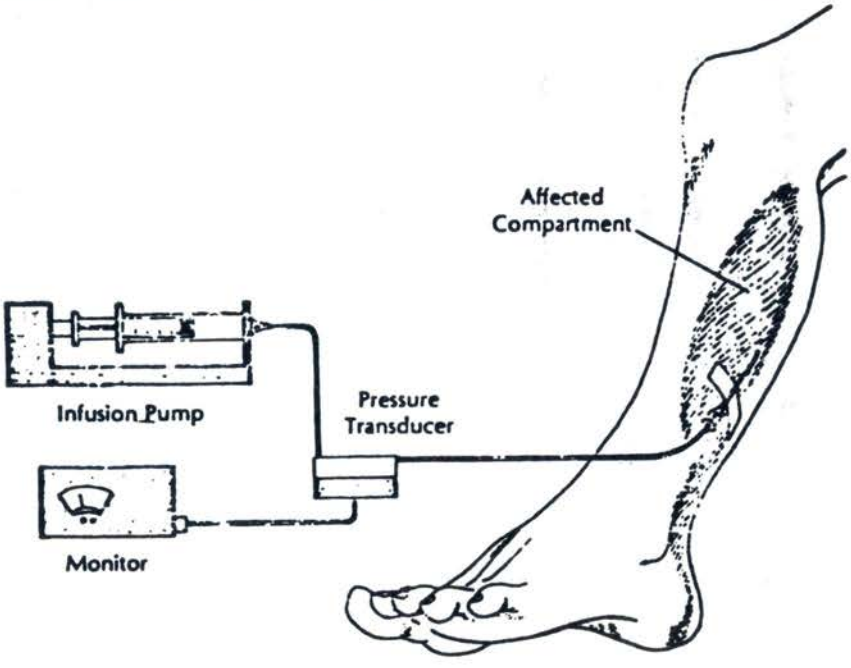

Figure 3.

Matsen's Continuous Infusion Technique uses pressure transducer and syringe-type pump that infuses sterile saline at 0.7cc/day.

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COMPARTMENT SYNDROME PATIENTS

Case	Name	Age/Sex	Cause	Findings	Compartments	Tissue Pressure (mm Hg.)
1.	R.D.	28/M	Fibular fx. (motorcycle)	Swelling, pain, but motor sensory & pulses	Ant. Leg Lat. Leg.	20
2.	J.R.	16/M	Contusion (motorcycle)	Swelling, pain & paresthesias, but motor & pulses intact	Sup. post. leg Deep post. leg	——
3.	C.V.	28/M	Open fxs. tibia/fib. (motorcycle)	Swelling, pain, but pulses motor & sensory intact	Ant. leg Lat. leg Sup. post leg	——
4.	B.T.	32/M	Tibial plateau fx. plus fib; MCL tear, fx. talus (fall on farm)	Swelling, pain, paresthesias, but pulses & motor intact	Ant. leg Lat. leg Sup. post leg	——
5.	D.B.	26/M	Open radial head & prox. ulnar fxs.; closed distal radius (motorcycle) + Thomas splint	Swelling, pain, paresthesias, but pulses & motor intact.	Volar forearm	——
6.	D.B.	26/M	Same (pronator tares or median nerve)	Same	Same	
7.	D.H.	23/M	Exercise (runner)	Swelling, pain, but pulses motor & sensory intact.	Deep post. leg	34
8.	B.C.	17/M	Contusion (football)	Swelling, pain, but pulses motor & sensory intact.	Ant. upper arm (brachialis)	80
9.	S.R.	29/M	Contusion of leg sprain, ankle	Swelling, pain, paresthesias, but pulses & motor intact.	Ant. leg	——
10.	E.H.	25/M	Contusion (Auto Accident)	Swelling, pain, paresthesias, but motor & pulses intact.	Sup. post. leg Deep post. leg	25
11.	P.H.	69/M	Contusion (anticoagulant)	Swelling, pain, but motor pulses & sensory intact.	Ant. upper arm (Brachialis)	——

indication for surgical decompression.[14]

2. How long can elevated tissue pressure in a compartment exist before there is significant permanent injury? Most compartment syndromes develop within the first 24 hours after an injury (usually 8-10 hours). There are reported cases that did not manifest themselves for 2-4 days after an injury.

Matsen feels that there is a 12 hour grace period after diagnosis of compartment syndrome before significant permanent injury develops.[15] Patients that had fasciotomy within 12 hours after diagnosis of compartment syndrome had only 32% incidence of abnormal function of muscles and nerves. Those that had fasciotomies after 12 hours had 92% incidence of residual functional deficits.[16]

Mubarek feels that the critical duration of compartment syndrome is 6-8 hours before fasciotomy should be performed.[17]

DIFFERENTIAL DIAGNOSIS

The differential diagnosis in patients with limb injuries and neurovascular deficits is primarily limited to: direct nerve contusion, arterial injuries, and compartment syndromes.[18]

A nerve injury usually does not cause increased tissue pressure and normal pulses are found. It is often associated with a fracture of contusion. It is most commonly a neurapraxia. The treatment of choice is observation.

An arterial injury usually presents with normal tissue pressures, but absent pulses. It requires repair of the artery or removal of the thrombosis immediately.

Compartment syndrome presents with increased tissue pressures, but intact pulses, and is treated by immediate fasciotomy.

The most important differentiating points are the pulses and compartment pressure measurements. Sometimes differentiation is difficult due to overlapping symptoms therefore, pressure monitoring and arteriography are important to sort out these entities.

TREATMENT

In any limb showing signs of a compartment syndrome circumferential dressings or casts should be removed. Garfen found that uni-valving the cast in dogs decreases tissue pressure by 85%.[19] Matsen believes that the limb should be placed at the level of the heart to assure that the local blood pressure is not compromised by elevation of the extremity.[20] These patients at risk are re-evaluated at frequent intervals. If the signs do not resolve, surgical decompression is usually indicated.

In times past the indication for fasciotomy and compartment syndromes was "when you are thinking about doing a fasciotomy, you should do it."

The surgery should be performed without tourniquet, otherwise ischemia will be prolonged and you will be unable to judge the response of the compartment to decompression. At the time of surgery, all involved fascial envelopes should be incised. This usually means that the skin as well as the fascia should be opened widely. Mubarak strongly recommends bringing the wick catheter device into surgery to make sure that the pressure has decreased in the compartment after fasciotomies have been performed.[21]

Kelley and Whitesides in 1967, stressed the importance of the four compartments and suggested subtotal fibulectomy-fasciotomy through a single, lateral incision.[22]

Mubarak suggested double incision fasciotomy because it required less dissection, was faster, and was relatively safer than the fibulectomy procedure.[22] The fibulectomy and double incision fasciotomy procedures are equally effective in decompressing the involved compartment.[22] They are usually used for four compartment involvement.

Occasionally, at about one week postoperatively the surgeon will need to debride the necrotic muscle and close the wound in a delayed fashion or apply skin graft.

Recently tibial fractures are being treated more frequently with external

Case	Fasciotomy	Skin Graft	Time From Accident to Admission	Time From Admission to Surgery (Hrs.)	Results
1.	Yes	Yes	2 days	24	good
2.	Yes	No	5 day	14	excellent
3.	Yes	No	——	2	excellent
4.	Yes	Yes	6 hrs.	10	good
5.	Yes	No	4 hrs.	1	poor
6.	Yes — Plus epimesiotomies & division of pronator tares	Yes	——	30	good
7.	Yes	No	Chronic	Chronic	excellent
8.	Yes	No — but delayed closure	1 hr. 1 hr.	2 2	excellent excellent
9.	No	No	8 days	——	excellent
10.	Yes	No	14 hrs.	24	excellent
11.	No	No	1 day	——	excellent

fixation devices. In a patient with compartment syndrome, this is certainly an aid in the care of wounds, while you are still able to control the fractures.

RESULTS

My interest in compartment syndromes was stimulated by the stress of caring for several of these patients during my first few years of practice. The following results are not satisfactorily significant due to the small number of patients, but they do seem to varify standardly accepted statistics from larger series. There are only 11 patients in this series, however, Matsen in his first series, (1976), there were only 44 patients over a 10 year period.

The average was 25 years (range of 16-32 years), and all were males, except for one lady 69 years old who developed a compartment syndrome in her upper arm from a severe contusion while taking anticoagulants.

In the male patients, 50% were associated with car or motorcycle accidents. 50% were caused by soft tissue contusions; 40% were caused by fractures and 1/2 of these were open fractures. All patients had significant swelling and pain; 60% had paresthesias. All patients had good peripheral pulses. All of the patients that subsequently needed surgery had pain on passive stretching of the involved muscles. The average number of compartments per patient in this series was 1.6.

The measurement of tissue pressure was not performed on all patients — several had fasciotomites at the time of initial care for open fractures. With the early cases, diagnosis was made on clinical grounds, but often the decision for when to do a fasciotomy seemed to be difficult to make. With experience and tissue pressure measurement, I gained more confidence in evaluating patients with equivocal presentation.

Fasciotomy was necessary in 9 of the 11 patients. Of the wounds that could not be closed at the time of the original surgery, 2/3 needed skin grafting and one was able to be closed secondarily at one week.

It was difficult to define the time of onset of compartment syndrome in these patients because most of them had a fairly complete presentation of compartment syndrome on admission to the hospital. Matsen suggested to do fasciotomy within 12 hours of the onset of the symptoms of compartment syndrome. He defined this point as the presence of muscle weakness, pain on passive muscle stretching and hypesthesias. The quality of pain of these patients was too variable to evaluate. In this series, the average time from admission to surgery for these patients was 13.4 hours. No significant functional deficits were found at follow-up.

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