VOLUME III No. 1 1984

# JOURNAL OF THE AMERICAN OSTEOPATHIC ACADEMY OF ORTHOPEDICS

PUBLISHED IN UNITED STATES OF AMERICA

JOURNAL OF THE AMERICAN OSTEOPATHIC ACADEMY OF ORTHOPEDICS Vol III No. 1


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VOLUME III, NUMBER 1, 1984

*Official Publication of the American Osteopathic Academy of Orthopedics*

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# JOURNAL OF THE AMERICAN OSTEOPATHIC ACADEMY OF ORTHOPEDICS

VOLUME III, NUMBER 1, 1984

*Official Publication of the American Osteopathic Academy of Orthopedics*

**CONTENTS**



*Journal of the American Osteopathic Academy of Orthopedics is published once a year in the Fall by the American Osteopathic Academy of Orthopedics, 1217 Salem Avenue, Dayton, Ohio 45406. Subscription rates for Vol. III, 1984: $10 in U.S. payment should accompany all orders. Please enclose present mailing label with all changes of address requests.*

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# Treatment of Unicameral Bone Cysts With Freeze-Dried Allografts

**Robert R. Kaneda, D.O., Harrisburg, Pennsylvania**

**ABSTRACT:** Since 1962 the United States Navy Bone Bank has contributed freeze-dried allograft bone for treatment of unicameral bone cysts. Two cases are presented which were successful treated by curettage and grafting with crushed cortical freeze-dried bone. Utilization of this type of bone obviates the need for a second procedure to harvest the autogenous graft and can supply larger volumes of bone. Results reviewed would indicate a comparable success rate to other forms of treatment. **KEY WORDS:** Freeze-dried allografts, Unicameral bone cysts.

## INTRODUCTION

The unicameral bone cyst is usually discovered incidentally as the result of a pathologic fracture through the cyst. It is most commonly found in the metaphyseal portion of the bone. The commonest location is in the humerus and the second most common is in the femur. Males are more commonly affected than females in a ratio of 1.7:1. The etiology is unknown.

The first mention of a solitary bone cyst was by Virchow in 1877. Elmslie was the first to offer a complete description of the lesion. Bloodgood[1] in 1910 wrote key article on cystic lesions in bone. The term unicameral bone cyst was coined by Jaffe and Lichtenstein.

Although the etiology is unknown, Monkeberg suggested in 1904 that these lesions were healing forms of a giant cell tumor of Osteitis Fibrosa. Originally Jaffe and Lichtenstein[2] proposed it was a local disturbance in bone growth and development. Broder stated that vascular obstruction in a focal lesion resulted in a bone cyst. Cohen in 1960 and 1970 related that the development of a cyst was caused by venous obstruction secondary to deficient venous drainage in that area.

Numerous forms of treatment have been proposed.[3,4,5,6,7,8] These span from benign neglect to total resection with bone grafting. Other forms of treatment include curettage with bone grafting, multiple drillings with Kirschner wires, subtotal resection with bone grafting and injection with Methyl Prednisolone.

The following case studies were discovered as a result of a pathologic fracture. They were initially treated with immobilization. The cysts failed to resolve, both were treated with Methyl Prednisolone injection and ultimately required curettage and bone grafting. In both cases a freeze-dried allograft was used.

Case Study Number One:

The patient was initially seen at age nine (11/5/75). She was on someone's shoulders and fell sustaining a fracture through the cyst in the metaphysis of the proximal right humerus. The cyst can be seen clearly in Figure 1. Initial treatment consisted of a sling and swathe. Healing of the fracture occurred at two months. On 5/7/76 she fell from a bicycle and sustained a second pathologic fracture of the right humerus. Treatment consisted of a sling and swathe. On 6/1/76 the cyst was curettaged and filled with freeze-dried allograft (Figure 2). Followup x-rays performed on 9/13/77 showed progression of the size of the lesion with apparent failure of the curettage and freeze-dried allograft. Injection of the cyst with Methyl Prednisolone was performed on 10/20/77. Despite these forms of treatment, the cyst continued to grow. A fall on 5/20/78 resulted in the third pathologic fracture. Treatment consisted of sling-and-swathe immobilization. She again injured her

right arm while sledding with, yet another fracture occurring. The cyst had continued to grow and now measured 4 x 12 cms. (Figure 3). The patient had two more fractures prior to her curettage and freeze-dried allografting of the cyst of the right humerus (Figure 4). On 3/18/82 the second curettage and freeze-dried allograft was performed. Within five months the bone graft consolidated and healed uneventfully with no recurrence (Figure 5).

Case Study Number Two:

This five-year old female was initially seen on 7/4/78 after sustaining a fracture through a cyst in the proximal left humerus (Figure 6). She was initially treated in a sling and swathe and later advanced to a cuff and collar. The fracture healed, but the cyst continued to expand. The cyst measured 5 x 2 cms. On 9/27/78 the patient underwent injection of the cyst with Methyl Prednisolone. Initially the cyst wall appeared to thicken, however, further serial x-rays substantiated recurrent thinning of the cyst walls. On 7/20/80 she struck her arm against a swimming pool ladder re-fracturing her left humerus. She was treated in a sling and swathe. Healing occurred in about two months. After fracture the cyst did not diminish in size. Currettage and freeze-dried allografting was performed on 8/20/82 (Figure 7). The cyst consolidated rapidly and at the two-year followup visit the cyst had filled in completely and the patient was at full activities without restrictions.

## DISCUSSION

Both cases presented occurred in the proximal metaphysis of the humerus, the commonest location for unicameral bone cysts.[4] Both sustained more than one pathologic fracture through the cyst, which were treated conservatively with a sling and swathe. The fractures healed in all instances with simple immobilization. In the followup x-rays, none of these fractures seemed to have any influence on the healing of the bone cysts. This is consistent with the thoughts of Edeiken and Hodes[9] who say "solitary bone cysts usually do not heal at maturity or after fracture." Jaffe also concludes that surgery is the

**Fig. 1 Case Study #1. (D. S.) Age 9+4 years with active cyst and pathological fracture. Note the proximity of the cyst to the epiphyseal plate.**

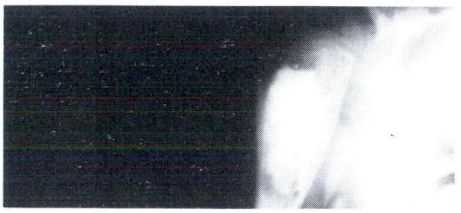

**Fig. 2 D. S. 9+11 years immediately following the first curettage and freeze-dried crushed cortical allograft. There is incomplete packing of the cyst both proximally and distally.**

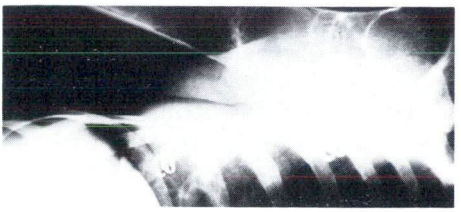

**Fig. 3 D. S. 15+6 years despite the allograft, which has reabsorbed, and the injection with Methyl Prednisolone the cyst continues to expand. Numerous pathologic fractures have deformed the bone.**

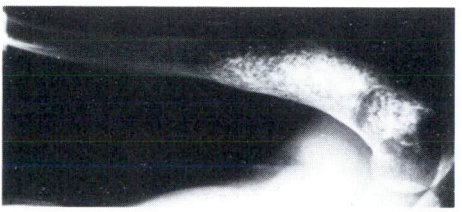

**Fig. 4 D. S. 15+8 years immediately following the second freeze-dried allograft. The cyst is now completely filled in contrast to the initial grafting seen in Fig. 1.**

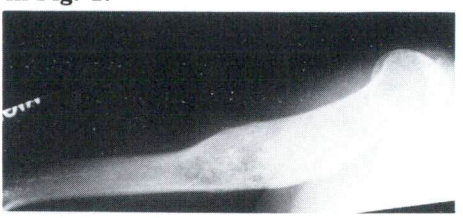

**Fig. 5 D. S. 18 years with resolution of the cst, but a slight static residual deformity on the distal end of the previous cystic defect.**

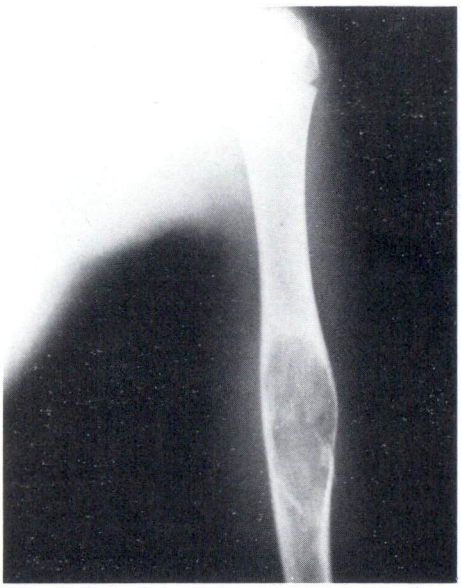

**Fig. 6 Case Study #1. (J.B.) 10 + 0 years illustrating a latent cyst located in the diaphysis of the humerus with a pathologic fracture.**

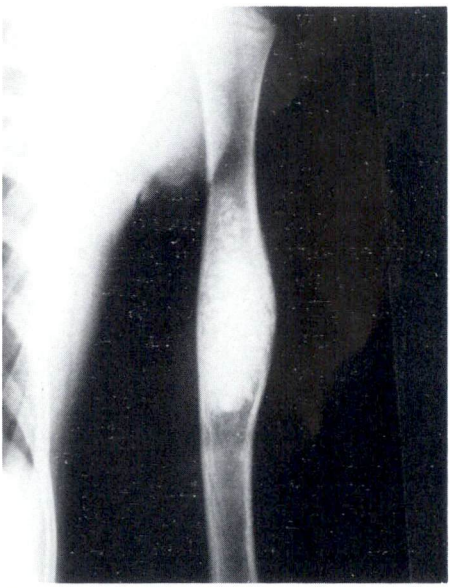

**Fig. 7 J. B. 10 + 2 years immediately following curettage and freeze-dried crushed cortical allograft.**

only definitive way to obliterate cystic defects of unicameral bone cysts. It is also Cohen's observation that these cysts invariably heal, but that no definitive studies have been done so that "the propensity of simple bone cysts to heal themselves cannot be quantitatively assessed, so as to evaluate any treatment."

Numerous factors have been explored which are believed to have an effect on the progression or success of treatment of unicameral bone cysts. These include age of the patient, site of predilection, latency or activity of the lesion, fracture through the cyst, sex of the patient, size of the cyst at the time of treatment and the type of treatment, including the timing of the treatment and technical expertise utilized in performing the procedure. The forms of treatment included immobilization in a sling and swathe, curettage and bone grafting with auto or allografting, injection with Methyl Prednisolone, subtotal resection with grafting, multiple drilling with K-wires, chemical cauterization with zinc chloride or phenol and filling of lesions with plaster of paris.

Curettage and bone grafting has been considered the standard form of operative treatment for the unicameral bone cyst. There is controversy that these lesions will heal after pathologic fracture.[3]

Fahey and O'Brien[6] stated that there was spontaneous healing of six cysts — all were in the humerus. Two were active and four were latent. In both cases presented there were at least six pathologic fractures in these two cysts and in each instance the cysts failed to resolve. Neer eventually abandoned immobilization and limitation of activities. The data obtained from these two patients does not favor conservative treatment either in the active or latent phase. As one can see, there is debate as to whether or not cysts will heal primarily.

The question then arises as to where to obtain the bone for grafting and should the bone be an autograft or allograft? There is the obvious problem of cosmesis with autografting and the necessity of a second incision. With larger cysts, autografts may not yield a sufficient quantity of bone. Since 1962, the United States Navy Bone Bank has supplied bone for unicameral bone cysts.[4] Initially these cysts were treated with freeze-dried cancellous bone. 177 were treated with a 64% success rate. 144 cases were treated with freeze-dried crushed cortical bone grafts and reported by Spence, et al. 98


**Fig. 8 J. B. 11 + 11 years with complete resolution of the cystic defect.**

**Fig. 9 J. B. The surgical scar at the time of the last followup visit. This can be further minimized by utilizing the medial approach advocated by Smith.**

of these healed primarily with no defect and 10 healed with a residual, but nonprogressive defect. Spence believes the most important factor in determining success of the procedure is the completeness of the packing of the cyst. When the completely packed cysts were evaluated the success rate was 88%, as compared to the overall success rate of 75%. This compares favorably with autologous grafting.

Fahey and O'Brien[6] reported a success rate of 95% healing with subtotal resection and bone grafting. This involves breaking down three-fourths of the diameter of the cyst wall. Strut grafts were then placed in the defect. The procedure is much more aggressive than curettage and bone grafting and yields only an 8% improvement. Campanacci and Scaglietti utilized corticosteroids in the treatment of bone cysts. A recent review in this journal related a success rate of 96%. The same double-needle technique with injection with Methyl Prenisolone was carried out, but both failed to heal and both continued to expand in size. A second injection was not attempted in either instance. No explanation can be found for failure of this technique. In both instances the needles were placed in the operating room with the aid of image intensification and straw-colored fluid removed with a syringe.

In case study number one, there were two operative procedures performed. When one reviews the postoperative x-rays, it is apparent that the distal end of the cyst is incompletely packed. Spence relates that this dramatically increases the rate of recurrence. The second operative procedure was performed and postoperative x-rays showed complete packing of the graft. Other factors to be considered which had changed from the time of procedure number one and two were the increasing distance of the cyst from the epiphyseal plate and the age of the patient. Both of these were more favorable in the second procedure. In both operations in case study number one, freeze-dried crushed cortical bone grafts were utilized. Though with the latter factors taken into consideration, one cannot conclude that incomplete packing is a primary factor in the cyst recurrence, it does support Spence's position.

Numerous papers[9,10,11] describe a lesion as latent or active. On review of most articles cited thus far, it refers to the proximity of the cyst to the epiphyseal plate. Observing Figures 1 and 2 the initial surgery would have a

poorer prognosis because the patient was under 10 years of age, a female, the cyst was in the active stage and it was incompletely packed. These were all factors cited as factors against a good result.

Neer and others,[3,12] feel that the results are improved in children over 10 years of age. This has been substantiated by the findings of Spence. In this study the recurrence rate of those under 10 years was 30% while in those over 10 years of age the rate of recurrence was 18%. "The positive correlation between age and healing was consistent regardless of activity (active or latent) of the cyst or sex of the patient." It is the author's feeling that it is the age of the patient, more so than the activity of the lesion, which is a greater determinate of the success of the procedure.

In case study number two the patient was greater than 10 years of age at the time of the procedure, the physis was closed, the lesion was in the latent stage and the cyst was completely packed. The lesion was much larger than in case study number one, but the above-mentioned factors favored consolidation of the cyst. The one factor which favored recurrence was that the patient was a female. The patient did heal the cyst after only one curettage and freeze-dried cortical allograft.

## SUMMARY

Two cases of unicameral bone cysts of the proximal humerus were presented. Both patients were females. Both were unsuccessfully treated with Methyl Prednisolone injections and both ultimately healed with curettage and freeze-dried crushed cortical allografts. Factors which encouraged bone cyst healing included the age of the patient, sex, latency or activity of the lesion and completeness of the packing of the cyst. Studies reviewed would indicate that treatment of bone cysts with this graft material compares favorably with autografts, but that the more radical subtotal resection with grafting may yield slightly better results than curettage and bone grafting alone. The data from injection of Methyl Prenisolone indicated a 96% rate of healing, but in neither of these patients was the treatment successful.

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## ACKNOWLEDGEMENT

*The author wishes to acknowledge the contributions of freeze-dried allograft material from the U. S. Navy Bone Bank. #3109.*

# Nine Year Experience With Total Knee Unicompartmental Arthroplasty and Review of Literature

**Gene D. Prendergast, D.O., Massion, Ohio**
**Dennis B. Kolarik, D.O., Massilon, Ohio**

## INTRODUCTION

Unconstrained unicompartmental arthroplasty was first introduced into the orthopedic literature in 1973 by L. Marmor. It is a polycentric prosthesis capable of replacing either the medial, lateral, or both tibial femoral compartments of the knee. The prosthesis reserves bone stock for future revision arthroplasty.[2-7] The sagacious council of reserving bone stock was reiterated by Coventry in his 1973 article regarding osteotomy about the knee.[18]

Subsequent to Marmors original paper, there has been a lack of unanimity in the literature concerning indications and the outcome of this procedure.[2-5-7-13] Currently, Marmor has outlined his indications for single unicompartmental arthroplasty as follows:

(1) Moderate to severe pain on walking
(2) Diagnosis of osteoarthritis, osteonecrosis, and traumatic arthritis
(3) Ligamentous stability
(4) X-Ray evidence of single compartment disease on weight bearing films

Marmor outlines contraindications for single unicompartmental arthroplasty as follows:

(1) Recent infection
(2) Young patients where osteotomies may be more helpful
(3) Extremely obese and active patients
(4) Evidence or medial or lateral subluxation
(5) Narrowing of the intracondylar notch on the tunnel view which may be indicative of bicompartmental disease
(6) Fixed varus or valgus deformities or flexion contractures of greater than 15° which may also indicate bicompartmental disease.[2]

Marmor has also outlined the following indications for double compartment arthroplasty as follows:

(1) Young patients with rheumatoid arthritis and destruction of the joint surface
(2) Young patients with osteoarthritis with minimal patellofemoral arthritis
(3) Any patient under 60 years of age who has loss of articular cartilage and moderate to severe pain

Contraindications for double compartment arthroplasty are as follows:

(1) Recent joint infection
(2) Obesity
(3) Charcot joint
(4) Severe patellofemoral disease
(5) Fixed severe varus or valgus deformity
(6) Patient over 60 years of age with severe joint disease
(7) Severe rheumatoid arthritis with marked osteoporosis in an older patient
(8) Marked ligamentous instability with medial-lateral subluxation.

The major indication for the unicompartmental prosthesis has really not changed much since the original article. Osteoarthritis and traumatic unicompartmental arthritis are still the most common indications for this type of prosthesis.[17] The indications and contraindications as outlined above are based primarily on a series of 552 knees operated between 1972 and 1981.[2]

Unicompartmental arthroplasty does not differ significantly from conventional total knee replacement arthroplasty with respect to pre-operative

work-up and post-operative management.[3] The complications of the unicompartment arthroplasty also do not differ greatly from those generally accepted for total knee replacement arthroplasty. Review of the literature has yielded some of the following observations with respect to post-operative problems.

Persistent patellofemoral irritation has been noted in Marmor's series. The cause has been traced to the fact that the femoral component often times was placed too far anteriorly over the femur causing persistent irritation against the patella. Marmor, in his series of 552 patients, noted that it was not uncommon for patellectomy to be performed post surgically for this type of problem[2]. Refinement of the surgical technique for placement of the femoral component has precluded this complication. Insall in his series also noted a large percentage of patellectomies post-operatively for problems with patello-femoral crepitance, and pain.[13] This too may have been attributable to improper placement of the femoral component. Dolibois and Mallory addressed chondromalacia of the patella post-operatively stating that is was often seen but that symptomatology was unusual.[15] Laskin in his series suggested lateral retinacular release and imbrication of the VMO to help avoid this problem.[10]

Sneppen documented a case of lateral dislocation of the patella following Marmor arthroplasty.[9] Marmor has suggested that unicompartmental arthroplasty be avoided in those patients with significant varus or valgus position of the knee. This abnormal alignment of the knee may indeed account for post-operative lateral dislocation of the patella.

Marmor indicated in his series a large incidence of failure of the 6 mm tibial prosthesis. He has since discontinued this tibial prosthesis sighting that the prosthesis itself was too thin to carry the load generated across the knee joint.[2]

Caution with respect to post-operative hematogenous infection has also been addressed by Marmor. He feels that patients undergoing gastrointestinal or genitourinary surgery post unicompartment arthroplasty are at significant risk for developing hematogenous born infections in their prosthetic knee. For this reason he advocates the prophylactic use of antibiotics for those patients undergoing dental or surgical procedures after they have had unicompartmental arthroplasty.[8]

Over-correction of varus or valgus deformity noted after unicompartmental arthroplasty has been sighted as a potential cause of failure. Marmor has commented that it is important to maintain the particular balance in the knee without shifting weight bearing to the unoperative compartment or causing translational instability in the knee. Laskin, in his series of unicompartment arthroplasty documented some failures which Marmor attributes to the fact that the arthroplasties may have indeed been over-corrected.[12-2]

Semi-constrained unicompartmental arthroplasties have received criticism for the fact that they do not allow the rotational component of knee flexion and extension to function in a physiologic manner. Indeed, it is felt that the semi-constrained, Gunston prosthesis leads to increased torsional force leading to early loosening.[5-14-16]

Insall and Walker found a high percentage of failure among medial compartment arthroplasties.[13] They concluded that the unicompartmental arthroplasty was primarily indicated for lateral compartment degenerative disease. They reported a high degree of success with lateral compartment arthroplasty. Marmor contradicted this statement in his series of 552 patients noting no difference in the results obtained from either medial or lateral compartment arthroplasties.[2] These results were further substantiated by Bae, et al in their recent review of 72 knees.[1]

## MATERIALS

A review of the operative records at Doctors Hospital Inc. of Stark County from May 1974 through February 1983 revealed that 109 surgeries were performed for unicompartmental or bicompartmental arthroplasty of the Marmor type. Four surgeons par-

ticipated in these surgeries (D.W.S., J.T.V., D.B.K., and M.L.C.) The technique of surgery was remarkably similar with respect to all four surgeons. Of 109 surgeries, 51 patients responded to a questionnaire and follow-up visit to the hospital with objective evaluation of their knees by an independent examiner. These 51 patients represented 63 surgeries. Of the total patients operated, three were known to have died at this reporting. One patient died immediately post-operative of a massive pulmonary embolus. One patient died of complications from chondrosarcoma related to his operative knee. One patient died of medical complications unrelated to the surgery.

Of 63 knees, 50 were operated for unicompartmenal disease, one lateral compartment arthroplasty and 49 medial compartment arthroplasties. There were 36 right knees and 14 left knees operated. The age of those patients operated for unicompartmental disease ranged from 39 to 82, with an average age of 67 years. The range of follow-up for unicompartmental arthroplasty was 1 to 9 years with an average follow-up of three years. One patient underwent concurrent Type III patellofemoral arthroplasty.

13 of 63 operated knees underwent bicompartmental arthroplasty. There were 6 right knees and 7 left knees operated. The age range of those patients undergoing bicompartmental arthroplasty was 32 to 84 with an average age of 69. Follow-up of those patients under going bicompartmental arthrosplasty ranged from 6 to 9 years. The average follow-up was 7.8 years. One patient underwent concurrent Type II patellofemoral replacement arthroplasty combined with Hauser procedure and bicompartmental arthroplasty.

Pre-operative evaluation of all 63 knees was reviewed by an independent examiner. An attempt was made to determine pre-operative valgus or varus alignment as well as stability. Average range of motions were obtained for the majority of the patients with regard to their pre-operative knee flexion and extension. Pre-operative diagnoses included osteoarthritis, traumatic arthritis, rheumatoid arthritis, and in the case of one patient, chondrosarcoma which was thought to represent osteonecrosis at the time of surgery.

## PROCEDURE

The majority of patients were operated for unicompartmental disease. The description of surgical technique which follows describes that approach used primarily for medial compartment arthroplasty. Lateral compartment arthroplasty was approached through a lateral parapatellar incision. Bicompartmental arthroplasty was usually approached through a single medial parapatellar incision. Occasionally, bicompartmental arthroplasty arthroplasty is performed through a medial and lateral parapatellar incision. One of our surgeons, (J.T.V.), oftentimes in order to assess the status of each compartment will precede this surgery with diagnostic and if indicated operative video-arthroscopy.

Unicompartmental arthroplasty for traumatic arthritis has received some special attention. Standing x-rays of knee joints with traumatic arthritis have been noted to be unreliable in terms of predicting unicompartmental arthroplasty.[7] It has been advised that patients undergoing possible unicompartmental arthroplasty for traumatic arthritis be advised of the possibility for surgical option of conventional total knee replacement arthroplasty.[7] Patients undergoing unicompartmental arthroplasty for lateral tibial plateau fractures should have complete evaluation of the medial collateral ligament. If MCL instability exists, it may be necessary to repair the media collateral ligament at the time of unicompartmental arthroplasty.[7]

The results of unicompartmental arthroplasty as documented by several authors have been somewhat varied. Marmor documented a 78° percent good to excellent result in his series of 552 knees.[2] Bae, et al in their series noted that pain relief was rated as excellent in 90% of the knees operated.[1] Dolibois and Mallory in their study of 12 patients noted that 11 of the 12 pa-

tients denied any significant pain post-operatively.[15] Laskin, in his original review of 89 patients, stated that patients received a striking post-operative relief of pain in both osteoarthritic and rheumatoid knees.[10] Later, in a follow-up of 37 patients with unicompartmental tibiofemoral resurfacing arthroplasty, Laskin stated that his overall results were definitely inferior to those seen in either bicompartmental or tricompartmental replacement arthroplasty. Laskin stated that they no longer used unicompartmental replacement arthroplasty on the medial side of the knee. Laskin further stated that results of three lateral compartment arthroplasties were good.[12] Insall and Walker reiterated, in their series of 24 patients, that medial compartment arthroplasty was not as successful as lateral compartment arthroplasty. Insall and Walker did not advocate the use of unicompartmental arthroplasty except for lateral compartment degeneration.[13]

Marmor addressed the problem of failure in unicompartmental arthroplasty indicating that the broader indications utilized for this type of surgery in years past may account for the high percentage of early failures.[2] Many candidates undergoing this procedure would not now be considered a candidate by todays indications. It is hoped that this investigation will contribute to the present evaluation of unicompartmental arthroplasty.

The procedure is performed under general or spinal anesthesia. On arrival to the operating room the patient receives 1 gram of Ancef(R) IV, if no contraindication exists. The knee is prepped with Betadine(R) for ten minutes and draped free. If no significant arteriosclerotic vascular disease exists, the leg is exsanguinated with an Esmarch bandage and a pneumatic tourniquet is inflated to 400 mm. Hg. with the knee in maximum flexion.

The procedure is begun with a standard medial parapatellar incision. The VMO is divided in its tendinous portion proximally. Distally the tibia is skeletalized to the MCL to facilitate exposure. Immediate gram stain and cultures are taken of the joint. The patella is everted laterally and the knee then flexed to 90°. A portion of the fat pad is excised to maximize exposure of the lateral compartment for inspection. Marginal and intracondylar osteophytes are excised from the femur and the patella. It is sometimes necessary to remove the anterior rim of the tibia to allow full extension of the knee post-operatively and facilitate removal of the posterior femoral condyle. 1/4 inch of the posterior femoral condyle is then osteotomized while the MCL is protected with a Cave retractor. The medial meniscus is excised. The appropriate tibial jig from the Mod II(R) Richards system is selected to approximate the size of the tibial prosthesis to be used. The largest tibial jig which fits comfortably in the space with a good rim of tibial plateau is selected. Using the jig, the tibial cut is outlined with methylene blue. A 5 mm. high speed burr is used to begin the tibial cut. A Pyrex(R) pie plate held over the knee will prevent contamination from flying debris. A rim of tibial plateau is preserved, especially posterior, to retain cement and hold the prosthesis in proper position. The superior surface of the tibial cut is perpendicular to the long axis of the tibia, and slightly declinated posteriorly. Medial inclination of the prosthesis is undesirable and precludes perfect apposition of the implant components. The cut is checked frequently for contour and maximum contact with the selected diameter unfooted tibial trial prosthesis. The tibial cut is completed with a 2.3 mm. round burr to square the edges of the basin. A trial tibial prosthesis of proper thickness is selected for trial reduction. The thickness selected does not over-correct any varus deformity. The MCL should be stressed at 30° with the tibial prosthesis to see that the fit is not too loose or too tight. The fenestrated tibial jig is then placed in the knee to outline with methylene blue the area for the tibial component foot. This footed trough is cut with the 2.3mm. burr drill. The trough is not cut too wide or too deep. (Press fit allows less toggle between the bone-cement interface.) Reduction with the appropriate trial

footed prosthesis will demonstrate proper fit. The prosthesis should not toggle in its tibial cut. It should fit firmly and flat with equal distribution of its inferior surface over the tibial basin created. The knee is extended and the most anterior edge of the femur which contacts the tibial prosthesis is marked with methylene blue. The tibial trial is removed. With the knee flexed, the smallest femoral jig which will fit the femur is selected. The anterior edge of the prosthesis should not extend beyond the blue mark over the anterior femur. The jig is centered over the medial femoral condyle so that its surface comes in maximum contact with the tibial component. The jig is hammered into place and a 3/8 inch drill is used to tap the anchoring hole in the femur for center post of the implant. The femoral jig is outlined with methylene blue circumferentially and in its fenestrated portion. The femoral jig is then removed. A 2.3 mm. round burr drill is used to cut the trough for the femoral component anchoring fins. The femoral surface is then prepared with the same burr, recessing the surface within the methylene blue outline to accommodate maximum contact of the femoral condyle with the trial prosthesis. The femoral prosthesis when impacted should lie flush with the femoral articular surface. A trial reduction with the implant tibial and femoral components is then performed and range of motion is checked with the patella reduced. The knee is checked for valgus and varus stability. The components are removed. Multiple cement fixation holes are drilled about the centered trough of the femur with a small burr. Copious normal saline irrigation with pulsatile lavage is performed prior to implant. The tibia and femur are then thoroughly dried. Both prosthesis are cemented in place at the same time using a plastic spatula or #15 blade scalpel to remove excess cement. The cement is finger packed into bone. Care is taken not to scratch the prosthetic surface. The cement cures with the knee in extension. Excess cement is removed after it has cured with a small osteotome and mallet. The wound is again copiously irrigated with normal saline and thoroughly explored for bone or cement debris. The pneumatic cuff is released and hemostasis is accomplished with electrocautery. The wound is closed in layers over a large bore hemovac in standard fashion. The wound is covered with a modified Jones dressing. The dressing and hemovac are removed in 24 hours, (J.T.V.) with range of motion and graduated weight bearing begun immediately therefter. All others being range of motion with graduated weight bearing after 48 hours. The patient is maintained on Ascriptin(R) post-operatively. During the hospital stay, prophylactic antibiotics are continued for five days post-operatively. Hospitalization after this procedure varies from 3 to 10 days dependent upon progression of range of motion. 90° flexion is considered adequate range of motion for the patient to be discharged. Range of motion is continued at home with protected weight bearing for six weeks. Beyond six weeks, the patient is encouraged to full weight bear.

## RESULTS

All knees were rated on a 12 point system. Four points were awarded for subjective evaluation, (Table I). Four points were awarded for objective evaluation of the knees, (Table II). Four points were awarded for radiographic criteria, (Table III). Patients with 0 to 3 points were graded as poor, patients with 4 to 6 points were graded as fair, patients with 7 to 9 points were graded as good, and patients with 10 to 12 points were graded as excellent. Percentages are based on surviving patients.

50 knees were evaluated for unicompartmental arthroplasty. Of those patients interviewed, 36 patients had an excellent result, 9 patients good results, 5 patients fair results, and no patients were graded as poor. One lateral unicompartmental arthroplasty was performed and 49 medial unicompartmental arthroplasties were performed. The average range of motion pre-operatively was 108°. The average range of motion post-operatively was 111°. One patient with a unicompart-

**TABLE I**

**Four point scale of subjective evaluation:**

| | | |
|---|---|---|
| **PAIN:** | **2** | **points awarded for no pain post-operatively.** |
| | **1** | **point awarded for rare or occasional pain with exercise post-operatively** |
| | **0** | **points awarded for pain requiring routine use of pain medication.** |
| **USE:** | **1** | **point awarded if the patient felt that they had greater use of the knee post-operatively.** |
| | **0** | **points awarded if the patient felt they had no increased use of the knee post-operatively.** |
| **AIDS:** | **1** | **point was awarded if the patient could walk comfortably without the use of cane or crutch in normal everyday activities.** |
| | **0** | **points were awarded if the patient could not walk unassisted during normal activities of daily living.** |

**TABLE II**

**Four point scale of objective evaluation:**

| | | |
|---|---|---|
| **LAXITY:** | **1** | **point awarded for patients without varus or valgus laxity greater than + 1.** |
| | **0** | **points awarded for varus or valgus laxity greater than + 1.** |
| **GAIT:** | **1** | **point awarded for ambulation without a limp.** |
| | **0** | **points awarded for patients with an antalgic gait in the operated extremity.** |
| **ROM:** | **1** | **point awarded for patients with a range of motion greater than 90° and an extensor lag not greater than 9°.** |
| | **0** | **points awarded to patients with a range of motion less than 90° or an extensor lag of 10° or more.** |
| **PAIN:** | **1** | **point awarded to patients with a painless range of motion and no pain with McMurry or modified McMurry stress test.** |
| | **0** | **points awards to those patients with painful ROM or pain with McMurry and modified McMurry test.** |

**TABLE III**

**Four point scale of radiographic criteria:**

| | | |
|---|---|---|
| **LUCENCIES:** | **1** | **point for no radiolucencies greater than 1mm.** |
| | **0** | **points for radiolucencies greater than 1mm.** |
| **TILT:** | **1** | **point awarded for x-rays without evidence of medial or lateral tilt involving either the femoral or tibial prosthesis.** |
| | **0** | **points awarded for any prosthesis with significant medial or lateral tilt. (Any prosthesis with anterior inclination also received 0 points.)** |
| **OSTEOPHYTE:** | **1** | **point awarded for evidence of significant osteophyte formation.** |
| | **0** | **points were awarded for the appearance of significant femoral or tibial osteophytes.** |
| **FAILURE:** | **1** | **point was awarded for no evidence of significant compartment narrowing, prosthesis failure or prosthesis deformation.** |
| | **0** | **points were awarded for any evidence of prosthesis failure, deformation or narrowing of the involved compartment.** |

mental arthroplasty required revision unicompartmental arthroplasty after two years because of component loosening. That patient is now five years post-operative and has an excellent result. One patient underwent a Type III patellofemoral replacement arthroplasty for previous patellectomy combined with medial compartment arthroplasty. That patient has an excellent result.(Fig. 1) One patient with a medial compartment arthroplasty required post-operative lateral retinacular release for persistent patellofemoral discomfort. After the lateral retinacular release the patient had complete resolution of her symptomatology. Her result at this time is noted as good. Five patients with unicompartmental arthroplasty were noted to have medial angulation of the tibial component. Three patients with medial tilt had fair results and two had a good result. One patient with a fair

result and medially tilted prosthesis was noted to have significant anterior inclination of the tibial prosthesis as well(Fig. 2 a&b) Two patients with fair results were noted to have significant osteophyte formation. Only one patient with a fair result was noted to have a 2 mm. radiolucency around the tibial prosthetic component as well as significant osteophyte formation. One patient with a fair result was noted to have inadequate separation of his tibia and femur. It is felt that this patients tibial prosthesis was not large enough to affect adequate separation of the femoral and tibial condyles. The majority of those patients undergoing unicompartmental arthroplasty had a preoperative diagnosis of either osteoarthritis or traumatic arthritis. One patient had chondrosarcoma which was diagnosed post-operatively.

13 knees were evaluated after bicompartmental arthroplasty with the Marmor prosthesis. Of those 13 patients, three patients had an excellent result, three patients had a good result, two patients had a fair result, and five patients had a poor result. The average pre-operative range of motion was 98°. The average post-operative range of motion was 92°.

Of five patients with bicompartmental arthroplasty classified as poor, one patient had removal of this prosthesis in his ninth post-operative year for infection. Two patients underwent revision conventional total knee arthroplasty and now have painless knees. One patient has since undergone two revision total knee arthroplasties and has a Guepar hinged prosthesis with a fair result. One patient with a poor bicompartmental arthroplasty result still retains his prosthesis. He is not anxious to be operated again. Radiographically, he is noted to have a deformed tibial prosthesis with poor placement of the medial femoral prosthetic component and circumferential osteophyte formation.(Fig. 3)

Two patients with bicompartmental arthroplasty had fair results. One patient is a juvenile rheumatoid arthritic with her prosthesis in place for nine years. The other patient has a seven

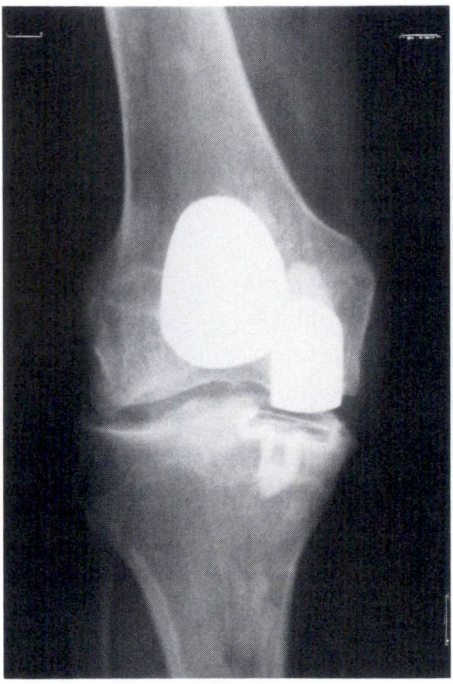

**FIGURE 1**

**This AP x-ray demonstrates a unicompartmental arthroplasty of the medial compartment combined with a type III patellofemoral prosthesis in a patient who had previously undergone a patellectomy.**

year follow-up with a pre-operative diagnosis of osteoarthritis. His compartments show significant narrowing with circumferential osteophyte formation. Neither patient complains of significant patellofemoral discomfort.

Interesting one patient with an excellent bicompartmental arthroplasty also underwent concurrent type II patellofemoral replacement arthroplasty and Hauser procedure.(Fig. 4) The patient is satisfied with the surgery.

## CONCLUSIONS

The results of unicompartmental arthroplasty performed in 50 knees over the past nine years demonstrated that 45 of 50 knees have excellent to good results. This represents a 90 percent success rate for unicompartmental arthroplasty. Five patients had a fair result and no patients in this series had a poor result. Only one patient underwent lateral compartment arthroplasty. Our results of those patients interviewed are comparable to the series described by Marmor, Dolibois and

**FIGURE 2A**

**This x-ray of a unicompartmental arthroplasty is from a patient with a fair result. Note in this AP projection the tibial prosthesis is tilted too far laterally.**

**FIGURE 2B**

**Note in this lateral projection of a unicompartmental arthroplasty with a fair result that the tibial prosthesis has an anterior inclination rather than the prescribed posterior declination.**

Walker, and Bae, et al.[1-2-15]

Unlike Marmor and Insall, we found no significant incidence of patellectomy post-operatively for patellofemoral discomfort.[2-13] We did note that many patients post-operatively did experience patellofemoral crepitation on objective examination, but related no significant symptomatology of patellofemoral disease. This finding corroborates that made by Dolibois and Mallory in that many patients have chondromalacia of the patella noted but are often asymptomatic.[15]

The average pre-operative range of motion for our series of patients under going unicompartmental arthroplasty is 108°. Post-operatively, the range of motion is 111°. This corresponds to Marmors finding that the average arc of motion post-operatively is 112° and not significantly changed from pre-operative motion.[2]

Unfortunately our results only include one patient with lateral compartment arthroplasty. We can conclude however that medial compartment arthroplasty is a very viable option for patients with medial compartment disease. This would contradict Insall's findings that lateral compartment arthroplasty is the most successful type of unicompartmental arthroplasty with medial compartment arthroplasty having less than desirable results.[13]

With respect to bicompartmental arthroplasty our results were more disappointing. Only 6 of 13 patients (46%) had a good to excellent result. Seven patients had a fair or poor result. Four of those patients with poor results required either revision arthroplasty or removal of the prosthetic components for infection.

## DISCUSSION

The results of this review of unicompartmental arthroplasty suggests that this is an excellent procedure when utilized for single compartment disease within the knee joint. The findings contradict those of other authors concerning poor success rates with medial compartment arthroplasty.

**FIGURE 3**

**This x-ray is from a patient with a poor result following bicompartmental arthroplasty. The medial tibial component has undergone deformation and the lateral femoral component has too much medial placement. This patient also has marginal kissing osteophytes which are not well demonstrated in this reproduction.**

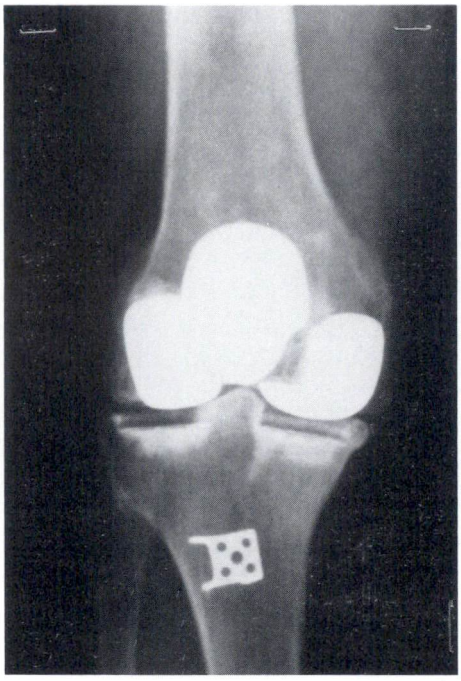

**FIGURE 4**

**This patient underwent a bicompartmental arthroplasty combined with a type II patellofemoral replacement arthroplasty and Hauser procedure. The placement of the lateral femoral component is less than desirable however the tibial components are in good alignment. This patient had an excellent result. This x-ray is a good example of the complexity involved in dealing with a multiplicity of articular surfaces.**

Patellofemoral degeneration has not proven to be a significant post operative problem in this sample of patients. No patient underwent patellectomy post-operatively.

Of those patients with fair results following unicompartmental arthroplasty, it is noted that the tibial component may have been placed in a tilted position. As outlined in the procedure, it is advocated that the tibial component be placed perpendicular with respect to the tibial axis with slight declination to approximate the normal physiologic position of the tibial plateau.(Fig. 5 a&b) Another procedural difficulty that has been found is femoral placement with respect to the tibial component. Occasionally, the femoral component may be placed such that only the medial or lateral portion of the metallic femoral component persistently contacts the tibial component throughout the range of motion. This has been likened to a car traveling on two wheels as performed by dare-devils in a stunt car show.(Fig. 6) It is felt that this incorrect placement of the femoral component will lead to excessive wear on the tibial component.

It has also been noted that two patients with fair results involving unicompartmental arthroplasty had circumferential osteophytes on the tibia and femur which may have contributed to their pain. Only one patient with unicompartmental arthroplasty that was reviewed had a radiolucency around the tibial component of greater than 2 mm. This patient had a fair result. In this radiographic review, persistent radiolucencies of approximately 1 mm. around the tibial component without significant symptomatology of patients was noted. This corrobrates Marmor's findings that 1 mm. of

**FIGURE 5A**

**This x-ray demonstrates proper placement of the tibial prosthesis in the AP plane. Note that the tibial component is perpendicular to the long axis of the tibia. The femoral component shows good contact with the tibial component in extension.**

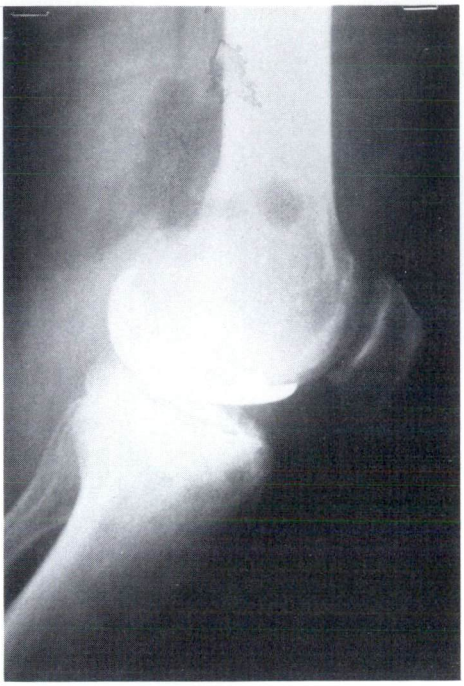

**FIGURE 5B**

**This x-ray demonstrates the slight posterior declination of the tibial prosthesis which mimics the normal alignment of the tibial plateau.**

radiolucency circumferentially about the tibial component has not been associated with pain or persistent adverse symptomatology.

Results of bicompartmental arthroplasty have been less successful than those of unicompartmental arthroplasty. Only 46% of our patients undergoing this procedure had an excellent to good result. Of those patients who have not had their prosthesis removed, but still have a fair or poor result, significant osteophyte formation within the intercondylar notch and circumferentially about the femur and tibia has been noted. No significant ligamentous instability was noted in any of the patients post-operatively. In one patient with two subsequent revisions arthroplasties it was retrospectively noted that she had significant ligamentous instability pre-operatively and in all likelihood was not a good candidate for this arthroplasty. This patient would tend to corroborate Marmors admonition not to perform this

**FIGURE 6**

**The medial tilt of this femoral prosthesis is incorrect. Contact between the femoral and tibial prosthesis will cause excessive wear. (This is reminiscent of a stunt car travelling on two wheels.)**

arthroplasty in patients with marked ligamentous instability.[2]

Placement of the femoral component with respect to the tibial components was less then desirable in two patients with poor or fair result undergoing bicompartmental arthroplasty. One patient with a poor bicompartmental arthroplasty was noted to have deformation of one of his tibial components with narrowing of the compartments.(Fig. 3) This is felt to be a contributing factor for that patient's painful knee. This patient does not wish to undergo revision arthroplasty. Interestingly, one patient with bicompartmental arthroplasty also had patellofemoral replacement arthroplasty performed simultaneously. This patient now has an excellent result after eight years follow-up.(Fig. 4)

Three patients with bicompartmental arthroplasty underwent revision total knee replacement arthroplasty. Two of those three patients have had good results following their revision arthroplasty. One patient needed to be revised a second time with a Guepar prosthesis due to marked ligamentous instability and now has a fair result. At the least, bone stock was preserved in all of these patients with regard to their subsequent arthroplasties.

Technically, in performing bicompartmental arthroplasty it is necessary to deal with four separate articular surfaces. The knee being the complex polycentric articulating surface that it is, it is not inconceivable that if these surfaces are not precisely positioned, the wear characteristics and ultimately the failure incidence can be influenced by small errors in placement.

This follow-up would suggest that bicompartmental arthroplasty has limited indications. The major indication should be young patient without significant osteoporosis, ligamentous instability and where preservation of bone stock is of primary importance. Surgical technique is important in choosing the correct prosthesis and placing it into the patient in the proper alignment.

As with any new procedure, the definition of indications is an ongoing process. Experience of this review indicates that medial compartment arthroplasty is a good surgical procedure for unicompartmental disease. This procedure, which if used with judicious application can give very satisfactory results. The major advantage of this type of arthroplasty whether unicompartmental or bicompartmental remains the preservation of bone stock. We advocate its use in patients in whom preservation of bone stock is of utmost importance and in cases where medial or femoral osteotomy may not be advantageous.

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# Positioning Techniques and Complications in Lumbar Spine Surgery

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**ABSTRACT:** Positioning Techniques and Complications in Lumbar Spine Surgery. In lumbar spine surgery there are four commonly used positions: Prone, lateral, knee-chest, and modified knee-chest. The sitting position has also been used in the past but is in disfavor because of the high incidence of air embolism. Each of these positions has various advantages and disadvantages physiologically to the patient. These factors (epidural bleeding, ventillation, surgical exposure, body habitus, etc.) influence how the surgery will progress and therefore color the prognosis.

Epidural bleeding during surgery is directly related to intra-abdominal pressure because of the valveless venous system (Batson's plexus). Therefore, the position that allows for the abdomen to be pendulous and dependent will allow for decreased bleeding. Di Stefano (Corr volume 99, 1974), compared laminectomy positions to inferior vena cava pressure (therefore bleeding). In order of increased pressure were: Modified knee-chest (Canadian frame), knee-chest position (Tuck, Rabbit, or Mohammedan praying position), prone position with Wilson frame, and lateral position. Ventillation is restricted least also in the modified-knee chest position. Exposure of the lumbar spine during surgery is facilitated by decreasing lumbar lordosis. This is found best in the knee-chest position, however, because of prolonged actue hip and knee flexion the patients do develop ischemia to muscles and nerves in the legs. This leads to release of myoglobin which can cause acute renal failure and death. The modified knee-chest position circumvents this problem by having hips and knees flexed only 70° to 80°. The latter position still allows adequate exposure. Careful placement of the patient is necessary in any of these positions to try to prevent muscular strains, contusions of peripheral nerves, hypotension, and thrombophlebitis. Slightly flexing the cervical spine, placing arms in the slightly flexed and abducted positions, wearing support stockings, and padding elbows and knees will help prevent some of these problems.

The optimal laminectomy position seems to be the modified knee-chest position (also known as the kneeling or prone-sitting position). The patient is prone with hips and knees flexed 70° to 90° each. Its main advantage is a marked diminution of bleeding. There have been many minor variations in this position: Canadian or Hastings frame, the knee-chest support (Laurin), Troncelliti frame, Andrews spinal surgery frame, and the Georgia prone frame. **KEY WORDS:** Spine, lumbosacral, intervertebral disc(s), lesions; surgery, position.

The optimal position for lumbar surgery is one which facilitates exposure, minimizes bleeding, and decreases the likelihood of injury to vital structures. This posture should permit the proper ventilation of the anesthetized patient, and yet not itself be a source of postoperative morbidity.

It is generally accepted that the most important determinant for success of any surgery lies in the choice of the patient pre-operatively. In lumbar spine surgery, this is determined by physical examination of the patient, observation of their response to conservative treatment, diagnostic tests such as lumbar myelograms and CT scans, and most importantly, the judgment of the surgeons. However, the position in which this surgery is performed can facilitate other factors that influence how this surgery will progress and, therefore, color the prognosis.

The purpose of his paper is to identify the factors that influence the progress of lumbar spine surgery, compare

them, and present recommendations to the practicing spinal surgeon. 100 consecutive cases of lumbar diskectomy at our hospital will be presented — using the modified knee-chest position.

For a point of personal reference to this problem, a survey of Orthopedic Surgeons, (Osteopathic) was performed. The questionnaire asked which position these Orthopods routinely used to perform lumbar fusions (figures 1 and 2). There were 122 responses out of approximately 200 Orthopedic Surgeons. There were 9 Orthopods that did not do fusions.

**Figure 1**
**Survey of Laminectomy Positions:**
122 Responses
40.1% Lateral Position
34.4% Prone Position
25.4% Modified Knee-Chest Position

**Figure 2**
**Survey of Fusion Positions:**
113 Responses
7.1% Lateral Position
57.5% Prone Position
35.4% Modified Knee-Chest Position

**BACKGROUND:**

The following factors influenced prognosis of lumbar spine surgery:

1. Exposure.
2. Bleeding.
3. Ventilation.
4. Body habitus.

The single most significant variable affecting the above factors seems to be the position of the patient during lumbar spine surgery.

2. **Exposure:** Exposure of the lumbar spine posteriorly is facilitated by any position which decreases lumbar lordosis. This allows easier entrance through the posterior elements to the contents of the spinal cord and the intervertebral disc space. The position which allows for maximal flexion of the lumbar spine is the knee-chest position. It is also called the Mohammedan Praying Position,[1] the rabbit or tuck position (figure 3).[2] The latter description is named for its resemblance to the tuck maneuver performed in gymnastics and diving.

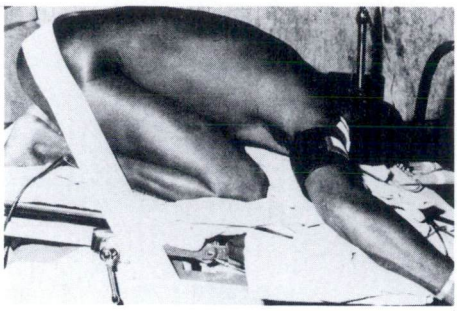

**Figure 3**
**The Tuck Position**

The knee-chest position has the advantage of allowing the abdomen to hang pendulous and thereby decreases epidural bleeding. The major objection to this position comes from the danger of prolonged acute hip and knee flexion. Patients do develop ischemia to muscles and nerves in the lower extremities from the tourniquet effect. This leads to release of myoglobin, which may cause acute renal failure.[3]

2. **Bleeding:** Bleeding from the vertebral venous system increases the difficulty of lumbar spine surgery because landmarks are obscured, operating time is prolonged, and vital structures are endangered. Blood loss is notoriously higher in obese and previously operated patients.

In 1940, Oscar Batson demonstrated the free communication of blood via a valve-less system between the epidural veins and the inferior vena cava through the intercostal, lumbar and

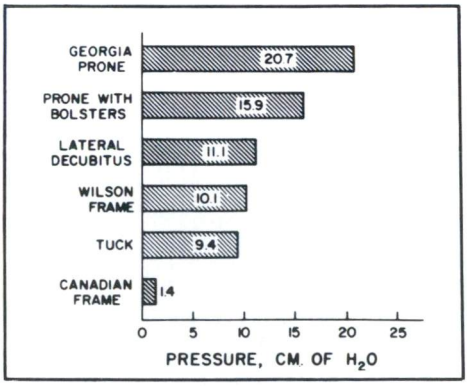


**Figure 4**
**Comparison of Positions to Inferior Vena Cava Pressures (DiStefano)**

other communicating veins.[4] The direction of flow in this system depends on the intra-abdominal pressure. The epidural veins normally drain into the inferior vena cava, but the flow can be reversed temporarily by the Valsalva maneuver (i.e., coughing, sneezing, defecation) or longer by body posture (e.g., laminectomy position).

In 1974, DiStefano compared the importance of body habitus and operative position to inferior vena cava pressure.[5] This pressure directly correlates with the condition of the vertebral venous system—hence, potential bleeding at surgery. The following 6 positions were compared: Georgia-Prone with bolsters, lateral decubitus, Wilson frame, tuck position and Canadian frame. Body habitus was quantitatively established by the use of skin fold calipers and then compared to each operative position. The pressure obtained in the frame were not significantly influenced by differences in body habitus. Figure 4 shows a bar graph comparing these positions to inferior vena cava pressures. The Hastings frame (figure 5) was found superior to the other positions with regard to inferior vena cava pressure.

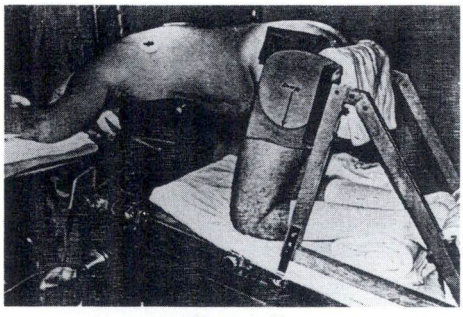

**Figure 5**
**The Canadian or Hastings Frame**

3. **Ventilation:** Laurin et al compared the volume of air exchange with an artificial respirator at fixed pressure when the patients were in various positions (supine, prone, and modified knee-chest).[6] The modified knee-chest position was found superior. The supine position was not as good because the diaphragm must work against the weight of the abdominal viscera. Simultaneous arterial blood gas determinations were also compared to these positions. Likewise, this showed improved arterial oxygen saturation in the modified knee-chest position compared to the other positions. It was thought that these respiratory advantages were even more obvious in the obese patient.

4. **Body habitus:** See above description by DiStefano under bleeding.[7]

The early postoperative complications after lumbar spine surgery can often be related to the position of the patient during surgery — especially his extremities. The tuck position was described above with its attendant problems. Hypotension and thrombophlebitis can develop in any patient that is immobilized for a prolonged length of time. This is due to pooling of blood in the lower extremities. It can be aided by compressive dressings on legs during and after surgery.[8]

Neurapraxia and muscular strains can develop when the patients are in awkward positions while anesthetized. Therefore, attention must be paid by the surgeon to careful positioning of the patient for surgery. The following positions of body parts often lead to neurapraxia and/or strains: Hyperextension of the cervical spine, hyperabduction of shoulders, acute flexion of hips and knees, excessive pressure at medial elbows and lateral knee areas.[9] Based on the above information, the author feels that the ideal position for lumbar spine surgery should include the following characteristics: 1. Pendulous abdomen. 2. Minimal respiratory restriction. 3. Arms slightly flexed and abducted. 4. Legs flexed 70-90°. 5. Pad elbows and knees. 6. Flex cervical and lumbar spines.

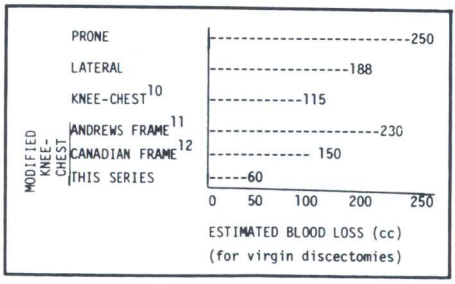


**Figure 6**
**Chart Comparing Laminectomy Positions to Estimated Blood Loss (Various Authors)**

**COMPARIONS OF POSITIONS FOR LUMBAR SPINE SURGERY:**

There are many aspects to this problem that may be compared. DiStefano compared operative positions and body habitus to inferior vena cava pressure. Comparison of blood loss at the time of lumbar spine surgery to various positions was made in figure 6. The estimated blood loss for each of these positions was measured by weighing the surgical sponges as soon as they were discarded and adding the volume of blood in the suction bottles. The figures for prone and lateral positions were based on 10 consecutive virgin laminectomies performed by Drs. Gerard Papp and Charles Hawes at Doctors Hospital, Columbus, Ohio. The other sources are adequately documented. These numbers are self-explanatory and seem to parallel the findings of DiStefano (figure 4). Hypotensive anesthesia and local infiltration of soft tissues of the spine prior to surgery with epinephrine solution were not used in any of these studies. Each series included in this chart limited the patients to those who had no previous lumbar spine surgery.

ADVANTAGES/DISADVANTAGES OF VARIOUS SPINAL POSITIONS:

| | BLEEDING | RESPIRATORY RESTRICTION | OBESE PATIENT | ISCHEMIA TO LEGS | LUMBAR LORDOSIS |
|---|---|---|---|---|---|
| PRONE | MOST | MOST | WORST | LEAST | MOST |
| LATERAL | | LEAST | BEST | | |
| KNEE-CHEST (OR TUCK) | | | | MOST | LEAST |
| MODIFIED KNEE-CHEST | LEAST | | | | |

(BLANK SPACES=INTERMEDIATE SEVERITY)

**Figure 7**
**(Blank Spaces = Intermediate Severity)**

Figure 7 shows a chart comparing the various operative positions to several important factors that influence the progress of lumbar spine surgery. This was made into a chart form from statements by Dr. Finneson in his book *"Low Back Pain"* and above review of the literature.[13]

In the 1950's the sitting position achieved some popularity.[14] It was thought that this position resulted in more free respirations and less epidural bleeding. The incidence of air embolism is high in this position. Currently, it is used infrequently.

The Relton-Hall frame is a modified prone position that is frequently used in scoliosis and other thoraco-lumbar spine surgery. (figure 8) It is the position that Mark Brown, M.D. PhD prefers for the above surgeries.[15]

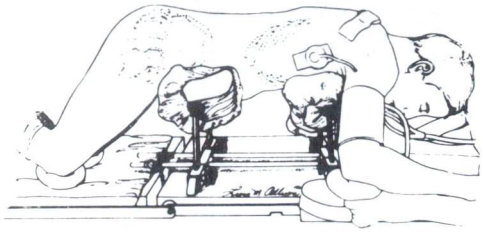

**Figure 8**
**The Relton-Hall Spinal Frame**

The modified knee-chest, kneeling, or prone-sitting position was first reported by Ecker in 1949.[16] Its main advantage is the marked diminution of bleeding from epidural veins due to the pendulous abdomen. There have been many minor variations in this position: Canadian or Hastings frame, the knee-chest support (Laurin),[17] Troncelliti frame, (figure 9),[18] the Andrews spinal surgery frame (figure 10)[19] and the Georgia prone frame (figure 11).[20]

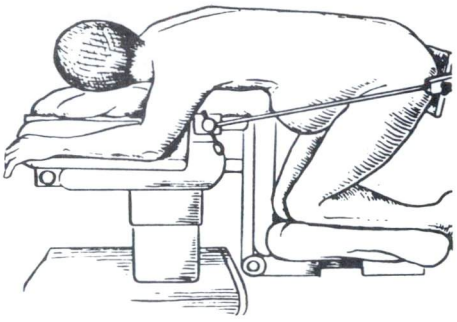

**Figure 9**
**Troncelliti Frame**

The Trent Andrews frame was first described in 1978, and deserves some special attention. It is very similar to the Georgia prone position. It requires less man power and strain to put the patient into this position compared to most other modified knee-chest positions. By a combination of gears and levers the patient can be placed in proper position. However, the estimated blood loss does not seem to be as good as other systems (figure 6).

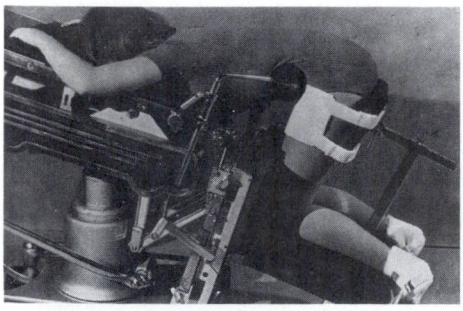

**Figure 10**
**Andrews Spinal Surgery Frame**

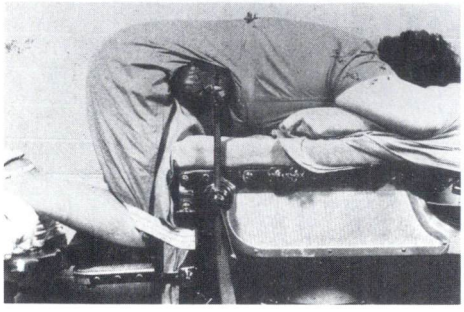

**Figure 11**
**Georgia Prone Position**

**TECHNIQUES OF POSITIONING PATIENT FOR MODIFIED KNEE-CHEST POSITION: (Figures 12-15):**

In our series of lumbar diskectomies, the modified knee-chest position was used. The technique of positioning the patient will be described:

The patient is intubated in the spine position on the gurney. The eyelids are taped closed and the endotracheal tube is taped in position. Foam pads are placed on the anterior aspect of the knees and the patient already has support stockings on legs. The patient is rolled into the prone position on the operating table. The anesthesiologist rechecks the blood pressure, applies cardiac monitoring electrodes and makes sure the patient is in stable condition (intubation tube does not move). The surgeon and assistant then simultaneously lift the pelvis and flex the legs into a modified knee-chest position. At the same time one nurse places blanket rolls under chest. The anesthesiologist controls the position of the neck and head. Another nurse inserts the buttock support and pad in position. This buttock support is part of the normal operating table (head support) that is taken to the distal part of the table and used as described above. The ischial tuberosities are supported by this frame. There is a ratchet adjustment on the buttock support for various sized patients. The blanket rolls are placed in a crossed position to each other with the blanket roll closest to the patient in a longitudinal fashion between the breasts and the blanket roll closest to the operating table placed perpendicular to this. The breasts are held lateral to the blanket rolls. The position of the knees and hips are about 70-80° flexed at each joint. Metal paddles are inserted lateral to the knees and the knees are protected with towels laterally. This prevents the knees from slipping off the table. The elbows and shoulders are placed in similarly comfortably flexed positions supported on arm boards and padded with towels at the medial aspect of the elbows. The operating table is placed into a reverse Trendelenburg position so that the spine is horizontal to the floor. No tape

**Figure 12**
**Rolling Intubated Patient From Litter to Operating Table.**

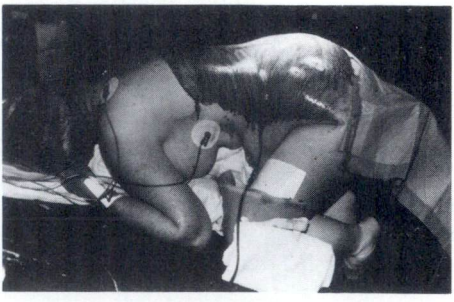

**Figure 13**
**Modified Knee-Chest Position**

is necessary to maintain this position. At this point, the surgeon rechecks the arms, legs and breasts for any undue pressure or circumferential restriction.

The surgeon palpates pedal pulses.

After surgery is completed, the assistant rolls the patient laterally onto the arms of the surgeon and the gurney. Simultaneously, the nurses straighten the arms and legs and the anesthesiologist controls the position of the neck and endotracheal tube. The surgeon can "walk" the patient up or down on the cart easily with his elbows. The patient is then in the supine position on the gurney and returned to the recovery room.

**Figure 14**

**Figure 15**

## RESULTS

Results are presented in figure 16. 100 lumbar diskectomies using the modified knee-chest position at our hospital were presented. These were performed by two Orthopedic Surgeons. These were mostly consecutive cases over a two year period except for 10 cases which were re-operated during this time. They had their original surgery prior to 1979. Their original figures were also compared to their present surgery. There were no complications (figure 17) directly related to positioning of the patient during surgery. The remaining complications are common to any laminectomy. It was beyond the scope of this paper to evaluate the causes of patients with poor results after this surgery.

**Figure 16**

**RESULTS (Modified Knee-Chest Position):**

100 consecutive cases
- 78 virgin
- 22 reoperated
- 74 males
- 26 females

Average Age—43 yrs. (15-82)

Average Wt.—169 lbs. (95-240)

Average EBL—66cc (20-350)
70% had < 60cc EBL
EBL virgin-60cc
EBL reop - 87cc

Average Op. Time—66min (27-122)
54% took < 60min
virgin - 63min
reop - 73min

**LEVELS OPERATED:**

41%-1 level/lside
59%-2 levels/bilateral

**HNP LEVELS:**

| | |
|---|---|
| $L_{3-4}$ | - 3% |
| $L_{4-5}$ | - 38% |
| $L_5$-$S_1$ | 40% |
| $L_{4-5}$ and $L_5$-$S_1$ | 19% |

**Figure 17**

**COMPLICATIONS:**

0 Neurapraxia

0 Hypotension

0 Thrombophlebitis

1 Polyuria—Addison's-type syndrome with low steroid level

1 Death by myocardial infarction 9th POD (was cared-cardiologist)

---

1 Distant cellulitis (pilonidal cyst)

1 Disc space infection

MANY Transient nerve root irritation

FEW Persistent nerve root irritation

Several lumbar fusions in the modified knee-chest position were performed during this period. However, the numbers were not large enough to be statistically significant. The general figures do correlate well with other

larger studies.[21] Patients that had diskectomies and fusion had estimated blood loss of approximately 1000 cc., operating time of 4-1/2 hours, and had 2 units of blood transfused during surgery. Patients that had lumbar fusion for spondylolisthesis had estimated blood loss of approximately 500 cc., operating time of 2-1/2 hours, and no tranfusions. The incidence of temporary leg paresthesias and/or neurapraxias was seen in nearly all patients. This was much higher than in patients with simple diskectomies. Most patients with this complication were better within a few days, but some had weakness for months. All did recover. It was felt that this complication was mainly related to immobilization of the patient because this has been seen in fusions in other positions. I was not able to find statistics to correlate this complication in various fusion positions. A few patients also developed adynamic ileus, but this resolved with appropriate treatment. No other complications with fusions were seen.

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**ACKNOWLEDGEMENTS**

The pictures and charts in figure 3,4,5,8,10,11 and 12 have been used in this paper with the permission of their respective authors and/or publishers. See the text of this paper and related footnotes for the proper acknowledgements.

# Primary Repair of Flexor Tendons Utilizing Dynamic Traction

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

**ABSTRACT:** The repair of flexor tendons has been a controversial topic, especially in so-called "no-man's land".[3] Delayed tendon grafting, primary repair with immobilization, and more recently, primary repair with early mobilization have been used to repair the ruptured or severed flexor tendons.

This study used the methods outlined by Kleinert, Lister, et al regarding primary repair of flexor tendons followed by immediate controlled mobilization.[4,5] **KEY WORDS:** Primary repair, controlled mobilization, dynamic traction.

## MATERIAL

Controlled mobilization with dynamic traction was performed on 82 of 100 patients who had primary repair of 225 flexor tendon lacerations. Of the 18 who were not treated with dynamic traction, 13 were children. Dynamic traction was not used in 5 adults due to revascularization or replantation (three) or, as in two cases, incomplete laceration of tendons which were splinted for approximately four weeks.

The average age was approximately 35 years, with the youngest being one year of age and the oldest being 64 years. The average length of follow-up was six months. The longest recheck was 27 months.

| TABLE 1 | | | |
|---|---|---|---|
| **Primary Flexor Tendon Repairs** | | **Primary Flexor Tendon Repair with Dynamic Traction** | |
| **Zone** | **Number** | **Zone** | **Number** |
| I | 20 | I | 20 |
| II | 128 | II | 97 |
| III | 27 | III | 11 |
| IV | 25 | IV | 23 |
| V | 25 | V | 24 |
| TOTAL | 225 | TOTAL | 175 |

The total number of tendons repaired in 100 patients was 225. In the 82 patients treated with dynamic traction, there were 175 tendon repairs. The specific zones of flexor tendon repairs are seen in Table 1.

In this series of 100 patients there was a rather large number (70) of patients who had associated injuries. These associated injuries ranged from common or digital nerve injury to crushing injury, fractures, skin loss, etc.

58 adults with associated injuries such as nerve, crush, arterial, etc., were treated with dynamic traction. See Table 2.

## TECHNIQUE

The same guidelines proposed by Lister, Kleinert, et al were followed in the primary surgical repair of flexor tendons.[4,5]

Under tourniquet control with axillary or general anesthesia, thorough debridement of contaminated wounds, extension of lacerations with Bruner zig-zag incisions[1] if necessary, and preservation of anatomical structures were performed. (Fig. 1,2)

Tendons were visualized at their proximal and distal lacerated points and held in position by a transversely placed 25 gauge needle in the proximal cut end. (Fig. 3)

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**TABLE 2**

| ASSOCIATED INJURIES | 70 of 100 Patients | 58 Treated With Dynamic Traction |
|---|---|---|
| Common or digital nerves | 60 | 49 |
| Common or digital arteries | 30 | 19 |
| Fractures | 4 | 4 |
| Crush injuries | 7 | 6 |
| Volar plate injuries | 2 | 2 |
| Other (median nerve, FCU or FCR, ulnar nerve or artery, extensor tendons, or skin loss) | 16 | 21 |

**Figure 1**
**Transverse Lacerations**

**Figure 2**
**Extension of transverse lacerations with zig-zag incisions.**

Meticulous handling of the tendon ends with atraumatic forceps was carried out. A modified Bunnell suture was initially placed[5] with 4-0 Ticron suture. (Fig. 4)

The tendon ends were approximated with this suture. "Bulging" or an "accordion effect"[4] was avoided. A 6-0 nylon continuous stitch was then placed in the epitenon and circumferential fashion at the tendon repair site under loop magnification to provide a smooth gliding surface (Fig. 5), and the tendon sheath was repaired with 6-0 nylon suture at this time.

Repair of neurovascular structures or internal fixation of a fracture was carried out at that time. Digital nerves were repaired, and end-to-end anastomoses or vein grafts were carried out on severed digital arteries. Bone fixation with either K-wires or intraosseous wiring was used for fracture care.[6]

At the conclusion of the repair, the tourniquet was released; and the 25 gauge needle was withdrawn. Hemostasis was achieved meticulously prior to skin closure.

As described by Lister[5] early mobilization was started. A 3-0 or 4-0 nylon suture was placed through the nail; and a rubber band, attached. Dorsal padded plaster splints were applied to the forearm, wrist and hand with the

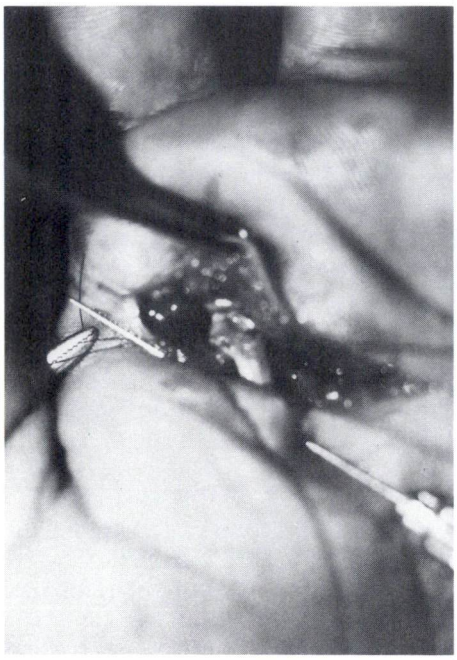

**Figure 3**
**25 Gauge needle placed in proximal tendon end.**

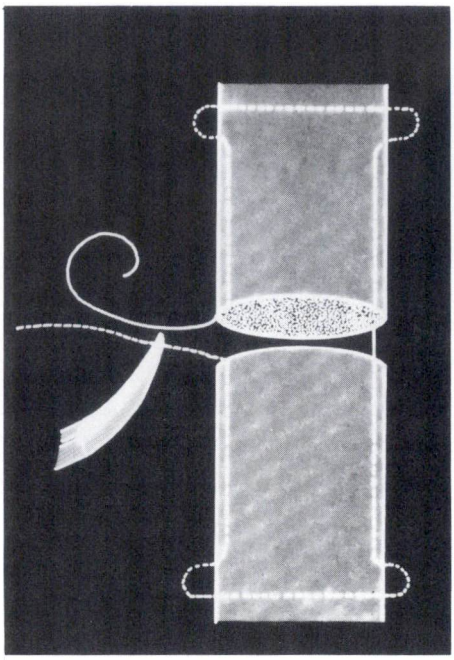

**Figure 4**
**Modified Bunnell Suture**

wrist in full flexion minus 30 degrees. The rubber bands were pinned to the volar portion of the dressing in appropriate alignment and with enough tension to allow full extension to the limits of the splint. (Fig. 6,7)

Active flexion of the fingers was forbidden as well as passive extension. Active flexion was only allowed under direct physician supervision.

Postoperatively, the patient was allowed three sets of ten active exten-

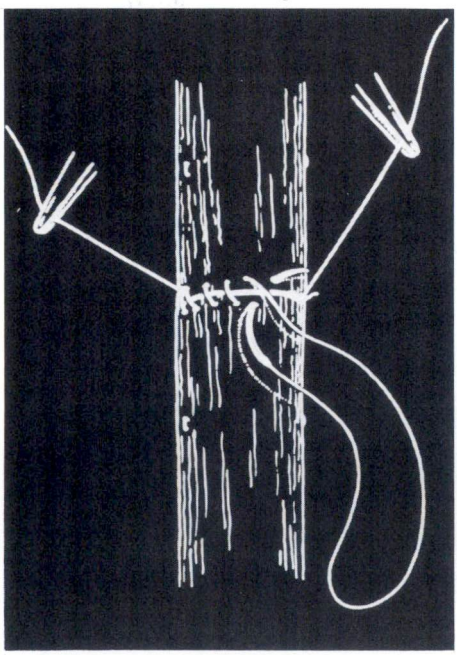

**Figure 5**
**6-0 nylon continuous epitenon suture.**

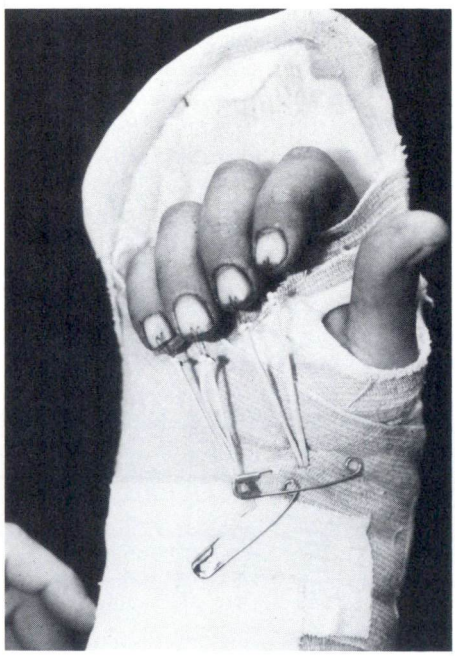

**Figure 6**
**Dynamic traction with rubber bands in place.**

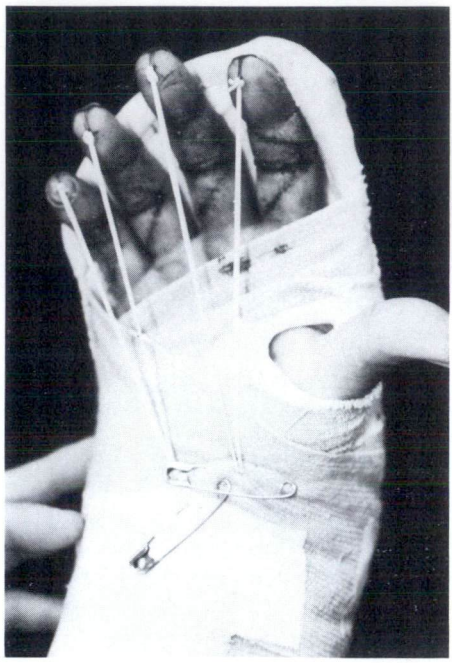

**Figure 7**
**Dynamic traction with extension of fingers.**

sion with passive flexion exercise daily with the operative splint worn for three weeks. The sutures were then removed and this dorsal splint was changed to one with the wrist in a neutral position for another two weeks with the continuation of three sets of ten motion exercises daily for each involved digit. At the end of five weeks, all plaster was removed; and an Ace wrap was then applied to the wrist and hand, attaching the rubber bands as before to the volar aspect of the wrist for an additional two weeks. Therefore, a total of seven weeks passed before removing the rubber band dynamic traction apparatus.

## RESULTS

Assessments of our results were based on Kleinert's criteria.[4] See Table 3.

The average length of follow-up in 100 patients was six months as previously stated. In 82 adults treated with dynamic traction, there were 63 (76%) excellent results, 11 good (13%), 6 fair (7%) and 2 poor (2%). Overall, in 100 patients treated with primary flexor tendon repair including 13 children and 5 adults not treated with dynamic traction, our results were as follows: Excellent 73 (73%), good 12 (12%), fair 6 (6%), poor 5 (5%).

Forty-six of the 82 patients treated with dynamic traction had Zone II lacerations with a total of 97 tendons involved. Good to excellent results were obtained in 89 (91%) of tendon repairs with 81 excellent (83%), 8 good (8%), and 6 fair (6%), with only 2 poor (2%).

In 82 adults treated with dynamic traction, there were six complications. They ranged from a tenolysis to flexor tendon rupture and four of the complications noted with dynamic traction dealt primarily with the return of sensation and motor function to the finger. These are all cited in Table 4. Overall, there was a 7% complication rate in those treated with dynamic traction. In the five adults not treated with dynamic traction, there were four complications including a failed replantation, one tenolysis, and two ruptured tendons. Generally these patients did have very severe crushing injuries or were revascularizations or replantations. There were no complications in the 13 children following primary flexor tendon repair. Overall in 100 patients, there was a 10% complication rate. Table 5 sites the overall results of

**TABLE 3**

**RESULTS: CLINICAL CRITERIA**

| | |
|---|---|
| EXCELLENT: | Flexon within 1 cm. of distal palmar crease with less than 15 degrees loss of extension. |
| GOOD: | Flexion within 1.5 cm. of distal palmar crease with less than 30 degrees loss of extension. |
| FAIR: | Flexion within 2-3 cm. of distal palmar crease with more than 30 degrees loss of extension but less than 50 degrees. |
| POOR: | Greater values of distance to distal palmar crease or extension loss or both. |

**TABLE 4**
**COMPLICATIONS**

| | Zone | Injury | Complication |
|---|---|---|---|
| 17 year old female | II | Incomplete ulnar nerve and flexor carpi ulnaris | Residual motor and changes at 4½ months. |
| 52 year old female | II | Crush injury right thumb ruptured volar plate, severed ulnar & radial digital nerve & artery. | Markedly decreased sensation at 6 months. |
| 29 year old male | II | Ulnar digital nerve right thumb, adductor tendon, right thumb. | Painful neuroma at 18 months. |
| 39 year old female | II | Lacerated common digital nerve, left ring finger, left small finger. | Two point discrimination greater than 25 mm. at 5 months. |
| 37 year old male | II | Severed flexor pollicis longus and radial digital nerve right thumb. | Ruptured tendon at 4 days after removal of D.T. (7 weeks and 4 days). |
| 31 year old male | II | Severed flexor digitorum sublimus and profundus right ring finger and right small finger. | Needed tenolysis & release of volar plates RRF and RSF. |

**TABLE 5**
**RESULTS**

| | Number of Patients | EX. % | Good % | Fair % | Poor % |
|---|---|---|---|---|---|
| Primary repair flexor tendon. | 100 | 73 (73) | 12 (12) | 6 (6) | 5 (5) |
| Primary repair flexor tendons Rx-Dynamic Traction | 82 | 63 (75) | 17 (13) | 6 (7) | 2 (2) |
| Zone II injuries Rx-Primary repair with Dynamic Traction | 46-97 tendons | 81 (83) | 8 (8) | 6 (6) | 2 (2) |

**CASE PRESENTATION**

The following represents an example of a patient with associated injuries and flexor tendon injuries treated with dynamic traction:

> D.O., a 33 year old Caucasian musician, sustained a power saw injury to his left hand with devascularization of the index and middle fingers. Both flexor tendons to each finger were severed, and there were open comminuted fractures present. The ulnar collateral ligament to the index finger was severed, and the extensor tendons were also involved. Vein grafting, primary tendon repair and nerve repair, and K-wire fixation were carried out. He was placed in rubber band dynamic traction two days later. Subsequently, a silastic implant was necessary for the proximal interphalangeal joint of the index finger. His two point discrimination returned to less than 10 mm. in each finger, and the result was excellent.

Figures 8 through 13 illustrate this case from the time to the initial injury, to the application of rubber band dynamic traction, and to the final result.

the patients with primary flexor tendon repair as well as the primary flexor tendon repair treated with dynamic traction, and also interestingly, the Zone II injuries treated with primary repair and dynamic traction.

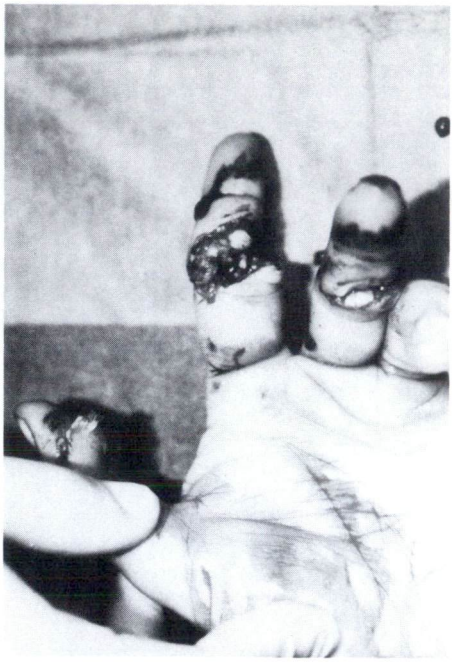

**Figure 8**
**D.O., 33 years old, male original injury.**

**Figure 9**
**D.O. Original x-ray of hand.**

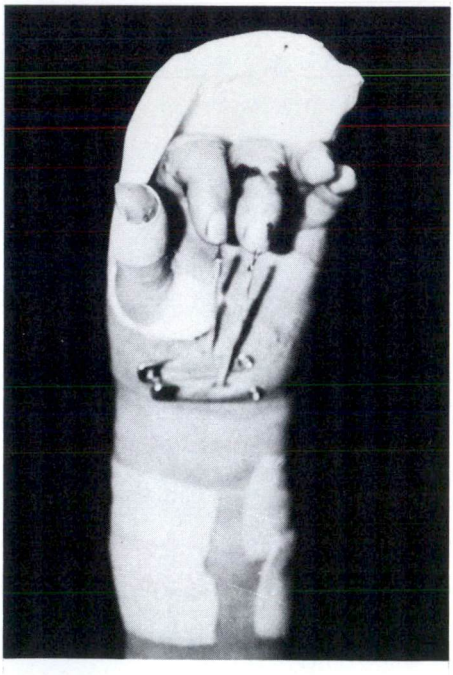

**Figure 10**
**D.O. immediate post-op dynamic traction-flexion.**

**Figure 11**
**D.O. post-op dynamic traction extension.**

## DISCUSSION:

Lister, Kleinert, et al have discussed the importance of technique when treating flexor tendon laceration with primary repair and dynamic traction.[4,5] In our series, there was a large percentage of associated injuries (83%), that being 58 of 70 patients who were treated with dynamic traction. These 58 patients were reviewed carefully.

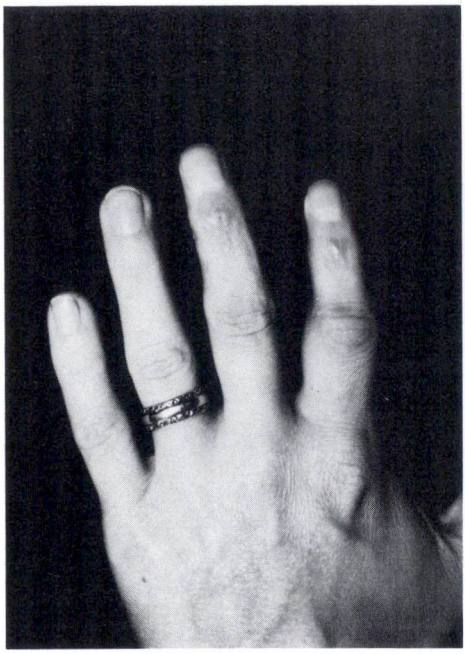

**Figure 12**
**D.O. follow-up extension.**

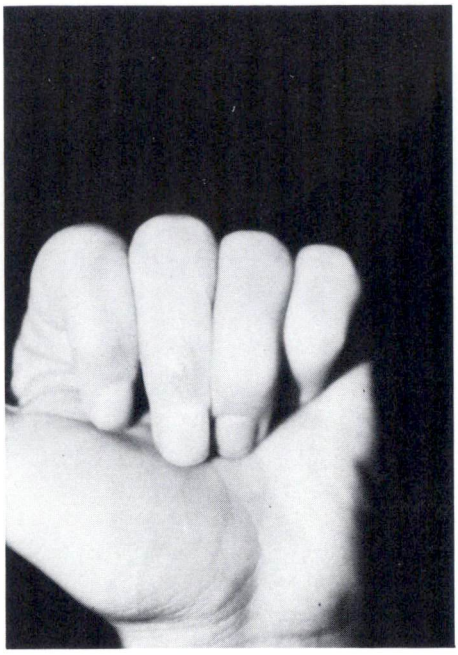

**Figure 13**
**D.O. follow-up flexion.**

Records were made regarding recovery of sensation, vascularity of the digits, etc. Two point discrimination, Tinel's sign, Allen's test, and temperature sensitivity were recorded.

Each type of associated injury was treated with dynamic traction. The position of the splint and fingers does prohibit extensive traction on repaired neurovascular structures, while the motion allowed in dynamic traction decreased the adhesive tendencies of the flexor tendons over phalangeal fractures.

Only approximately 8% of the patients with associated injuries developed complications; therefore, we feel there were no adverse effects with early mobilization in treating associated injuries.

We did keep our patients in dynamic traction longer than previous reports.[4,5] A total of seven weeks rather than three to four weeks was our treatment of choice. We continued the dynamic traction longer for several reasons. The technique of primary flexor tendon repair should result in minimal tension at the anastomosis, avoiding the "accordion effect".[4] Ketchum[2] states "tendons with minimal tension at the site of repair are weaker at three weeks than those with significant tension, but this strength increases rapidly over the following three weeks."[2 (p. 433)] Secondly, flexor tendon injuries occurred generally in younger people. We feel that too early active mobilization in young people without control would have resulted in a far greater number of tendon rupture.

Primary repair of flexor tendons in this series, especially when followed by use of rubber band dynamic traction, has achieved a very high success rate. Only when performed by experienced surgeons under controlled conditions with meticulous technique, can a high probability of success be assured.

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# Treatment of Adult Diaphyseal Fractures of the Radius and Ulna Utilizing Dynamic Compression Plate Fixation

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**ABSTRACT:** Twenty adult patients with twenty-eight diaphyseal forearm fractures were treated at Garden City Hospital utilizing the ASIF dynamic compression plate (DCP) technique. The average age at surgery was 27.4 years and 80% of the patients were seen in long term follow-up averaging 8.9 years. All fractures united and no patient lost more than 30% of pronation/supination. Five and six hole plates were used in the majority of cases (20/22). Primary bone grafting was used in nine cases, including four non-unions of the ulna, and five fractures which involved comminution of more than one-third the shaft circumference. Postoperative immobilization and routine plate removal were not found necessary. **KEY WORDS:** Dynamic Compression Plate, Forearm Fractures, Radius and Ulna Fractures.

## INTRODUCTION

Adult diaphyseal fractures of the radius and ulna present unique problems in management not encountered in other long bones. Opposing muscles exert rotatory as well as angulatory forces, resulting in high rates of non-union and mal-union. Anatomic reduction is therefore required to achieve both union and the complex motion of pronation and supination.

## HISTORY

Closed methods have generally met with little success (8, 31). Knight and Purvis found 71% of both bone forearms treated in this manner unsatisfactory. Hughston, reporting on radial shaft fractures, found an unsatisfactory rate of 92% when treated closed.

Open reduction without internal fixation was attempted in earlier years with a failure rate of 85% (20). Primary onlay graft was added at the time of open reduction, with somewhat better results but increased the chance of synostosis (20).

Many techniques of internal fixation have been used. Intra-medullary devices such as Kirshner Wires (20), Rush Rods (19, 20, 25), and Sage Nails (26, 29) resulted in high rates of non-union and severe limitations in forearm motion. Smith and Sage recorded non-unions overall of 20%, with severe loss of motion in one-third of 338 patients with 555 fractures treated with the Sage Nail.

Internal fixation with plates and screws gained popularity with the improvement in non-reactive metals. The early results, however, were little improved over previous methods discussed. Knight & Purvis (1949) reported 65% unsatisfactory results in 20 fractures treated with plates. Delayed and non-union were felt to be a result of inadequate plate and screw length.

Eggers (1949) developed an "Internal

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Contact Splint" that used plates with slotted holes in which the screws were not tightened. Contraction by the forearm muscles would then allow the fragments to slide together and maintain compression. Although subsequent authors (8, 19) reported good results with non-union less than 8%, the technique was not universally accepted as long periods of immobilization were required.

Rigid internal fixation with plates and screws evolved to consistently produce non-union rates less than 10% (7, 17, 27). The "compression" plate, introduced by Danis (10) and perfected by Muller (22) proved to be the most effective internal fixation device. Non-union rates of less than 3% could then be achieved (1, 3, 12, 15, 23, 27, 31).

Compression plating initially involved usage of the tension device as seen in Figure 1. This has generally been replaced by the Dynamic Compression Plate (DCP), illustrated in Figure 2. The DCP achieves axial compression without the use of the tension device. It is technically simpler to use, requires less exposure, and is more adaptable to different situations involving internal fixation.

The purpose of this paper is to report our experience with dynamic compression plating of adult diaphyseal forearm fractures, as outlined by the Association for the Study of Internal Fixation (ASIF). This study represents the longest average follow-up for this type of treatment reported in the literature.

## METHODS AND MATERIALS

During the period 1973 to 1977, twenty adult patients with twenty-eight diaphyseal forearm fractures were treated utilizing the ASIF dynamic compression plate (DCP) technique (Table 1). All patients were seen initially in a study in 1978. Sixteen of twenty (80%) were again seen in a long term follow-up averaging 8.9 years.

The average age at the time of surgery was 27.4 years, with a range of 15 to 56. Male to female ratio was 1.5/1.0. Right and left extremities were involved evenly at 10/10.

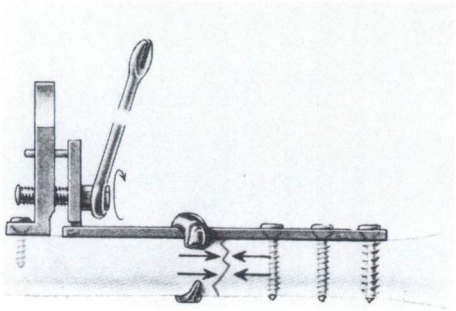


**FIGURE 1**

**Tension Device: This device is generally unnecessary with proper use of the DCP.**

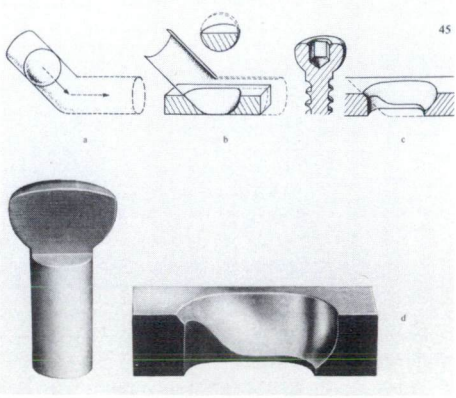


**FIGURE 2**

**The spherical head slides down the screw hole much as a ball would roll down an inclined cylinder as the screw is inserted (Top Figure).**

**Dynamic Compression Plate. The configuration of the screw and hole of the DCP are illustrated (Bottom Figure).**

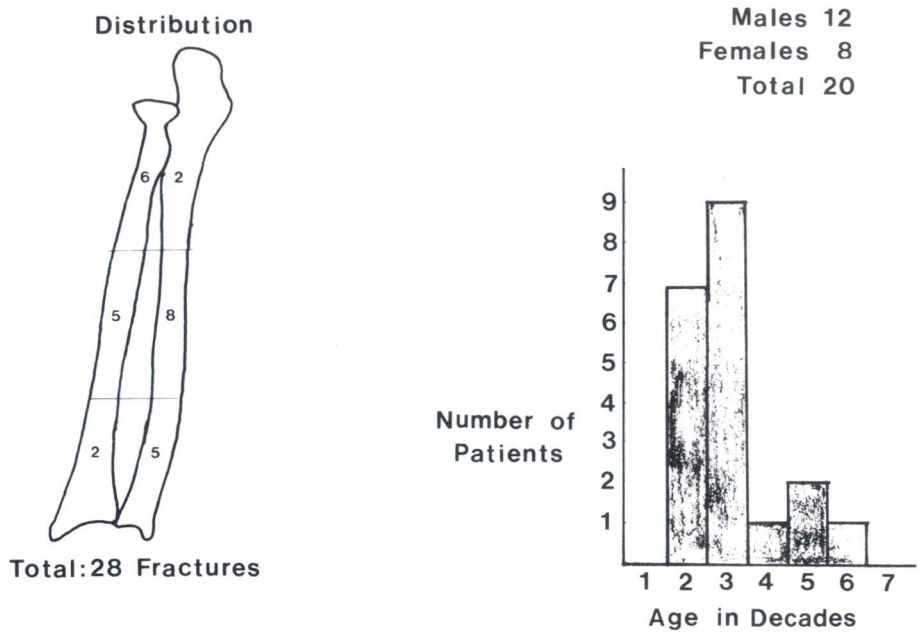
Of the twenty patients, eight had fractures of both bones, ten fractured the ulna only, and two fractured only the radius. There were four Monteggia fractures, one Galleazzi, and four non-unions. All the non-unions were of the ulna treated initially with an intramedullary rod (Figure 3).

All fractures but two were closed. The two open fractures in this series were of the ulna and were treated closed.

Of the twenty-eight fractures, twenty-two were internally fixed and six were treated by closed reduction. A four hole plate was used twice, five hole plates were used fifteen times, and six hole plates five times.

Any fracture with comminution involving more than one-third the circumference of the shaft (Anderson) or

TABLE 1




any non-unions were primarily grafted with autogenous iliac cancellous bone. Two fractures of the radius and six fractures of the ulna were grafted in this manner in conjunction with compression plating. Four grafts were used with five hole plates, and four grafts were used with six hole plates.

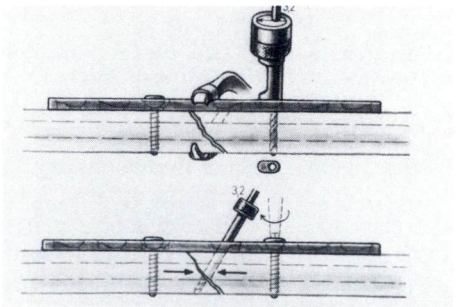


**FIGURE 2(b)**

**Axial compression is therefore obtained as the screw (and bone) move relative to the stationary plate. (Reproduced from Muller et at, Manual of Internal Fixation.)**

## SURGICAL TECHNIQUE

The surgical approaches utilized are as described in Campbell's Operative Orthopedics (2). In regard to the radius, plating for proximal fractures is achieved through a dorsal approach, with less likelihood of injuring the radial nerve or creating a mechanical block to pronation. Distal radial fractures use an anterior Henry approach. The plate is applied to the volar surface where the soft tissue coverage is better and the bone surface is flatter than on the dorsal aspect. Middle third fractures use either approach.

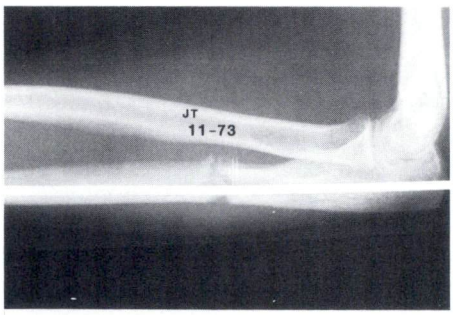



**FIGURE 3(a)**

**Seventeen year old female with non-union of ulna treated initially with I-M Rod.**

The ulna is incised along the subcutaneous border with the plate placed anteriorly or posteriorly, selecting the surface on which it best fits.

The limited surgical exposure used need only be as long as the desired length of the plate. The periosteum is

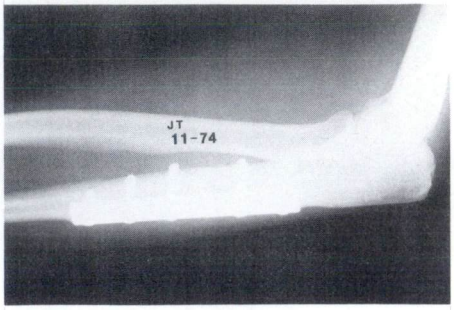



**FIGURE 3(b)**

**Bone grafting was performed with compression plating. The "asymptomatic" plate was routinely removed at one year.**

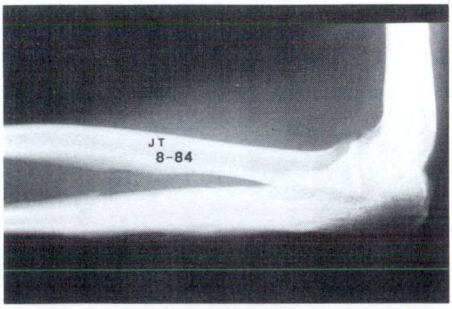



**FIGURE 3(c)**

**Ten years after the initial surgery the patient has a painless full range of motion.**

not stripped if at all possible, and the fracture is reduced anatomically.

The principles and techniques of DCP application were followed as outlined in Muller (22). Four hole plates were used only with transverse fractures (Figure 4). If significant comminution or obliquity was noted, five or six hole plates were then used. The rule of thumb used for adequate plate fixation was at least five cortices engaged in each main fragment.

Fractures of the distal third of the radius may be associated with dislocation of the radio-ulnar joint (Galleazzi-type, Figure 5). After reduction and plating of the radius, the distal ulna usually reduces anatomically with no need for internal fixation.

Fractures of the proximal third of the ulna may also be associated with dislocation of the radial head (Monteggia-type, Figure 6). The ulna is plated and closed reduction of the radial head is attempted. If unsuccessful then open reduction is carried out through the Boyd approach. If the radial head is comminuted, then it is resected and replaced with a silastic implant (Weingarden).

Postoperatively, all fractures were immobilized with long arm casts from four to nine weeks, averaging 5.7 weeks.

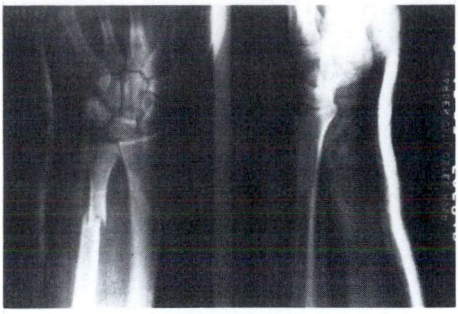


**FIGURE 4(a)**

**Transverse fracture of distal ulna. This is the only fracture type where a 4 hole plate was used.**

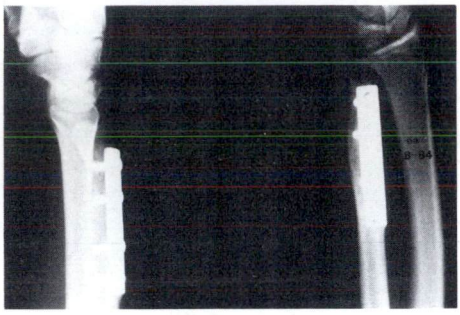


**FIGURE 4(b)**

**Eight years later the plate remains asymptomatic with full motion.**

## RESULTS

The specific goals of treatment are 1) union, and 2) restoration of function. The criteria used for assessing results were those of Naimen, et al (23), and are as follows: *excellent* — union, with less than 10% loss of pronation/supination, and no major subjective complaints; *good* — union, 10-30% loss of motion, with mild complaints; and *poor* — non-union or greater than 30% loss of motion or moderate to severe complaints.

Union was achieved in all patients. The average healing time was eight weeks, and was designated by obliteration of the fracture line with bridging trabeculae. The nine year follow-up of sixteen patients found eleven patients with an excellent result, five were grad-

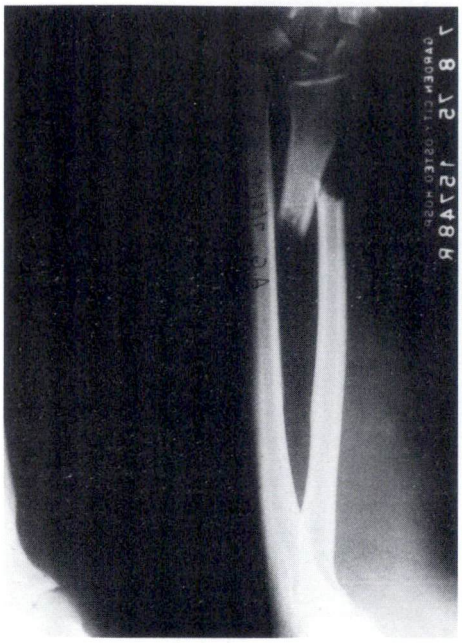


**FIGURE 5(a)**
**Galleazzi Type.**

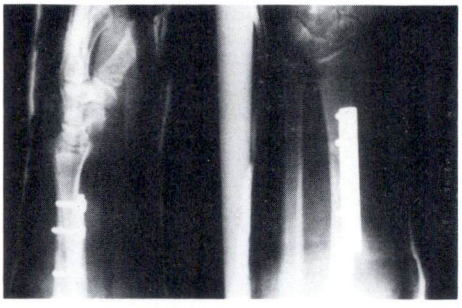


**FIGURE 5(b)**
**The distal ulna reduced with plating of the radius.**

ed good and none were rated poor. All good results achieved union, but had residual loss of motion or mild subjective complaints.

Only six of twenty-two plates were removed, none of which were symptomatic. The average length of time before removal was 1.5 years. No refractures were noted.

No patients became infected, with 40% receiving prophylactic antibiotics.

Two patients had Monteggia fractures in which the radial head was comminuted. The first patient's prosthesis fractured and was removed six months after insertion. He subsequently went on to a good result with 25-30% loss of forearm motion.

Long term follow-up on the second patient showed his prosthesis had displaced (Figure 6). Although significant crepitus was noted on elbow motion, the patient was asymptomatic and had less than 30% loss of forearm motion (good result).

Four patients had transient sensory nerve palsies (one radial and three ulna) all of which resolved within one year.

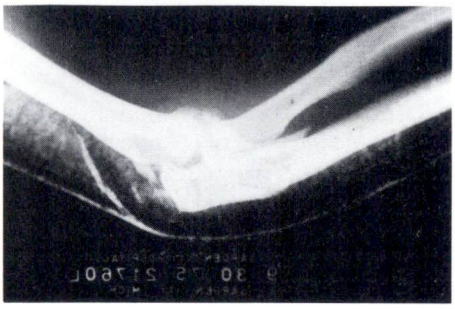


**FIGURE 6(a)**
**Monteggia Type (a).**

**FIGURE 6(b)**
**The comminuted radial head was resected and a silastic prosthesis was inserted.**

## DISCUSSION

Rigid internal fixation utilizing the ASIF technique has several advantages. The impacted bone ends are stabilized protecting the developing blood supply. Compression diminishes

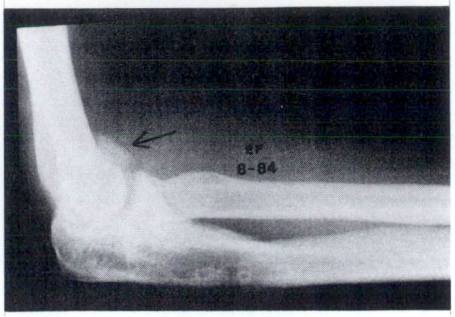



**FIGURE 6(c)**

**Eight years later the patient has a good result despite fracturing and displacing the prosthesis.**

the space between the fragments that must be bridged by new bone. Primary bone healing then occurs by direct extension of capillaries and haversian systems across the fracture site. Union is thereby produced without a cartilaginous or enchondral phase, and callous formation plays little part in the healing process.

Compression has also been shown by Bassett and Ruedi (6) to stimulate differentiation of mesenchymal cells into osteoblasts by producing a high oxygen tension. Distraction, conversely, produces a low oxygen tension and favors fibrous tissue cells.

Non-union risk factors, as identified by De Buren (11) include, a) severe initial displacement, b) involving both bones, c) treatment with casting, d) open fractures, and e) comminuted fractures. Primary bone grafting with comminution is somewhat controversial with some authors (23, 27) achieving 100% union without grafting. We have followed Anderson's protocol, primarily grafting when the comminution involves more than one-third the shaft circumference (Figure 7). Cancellous iliac grafts were applied to five such fractures with union achieved in all.

Single plating was used in all our cases and found to be adequate. Teipner and Mast (31) compared double v.s. single plating and found equal results overall, with single plating requiring less surgical time and less devitalization of tissue.

Stern and Drury (30) related the number of screws to non-union and found a non-union rate four times

**FIGURE 7(a)**

**Nineteen year old male with comminution of the distal radius.**

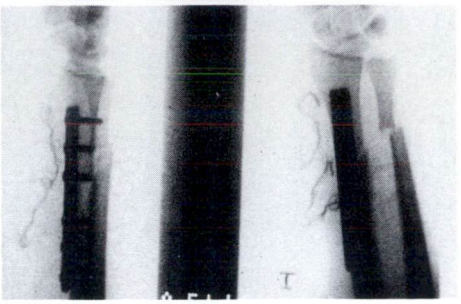


**FIGURE 7(b)**

**Primary bone grafting was performed with compression plating. Fractures with comminution involving more than one-third the shaft circumstance were treated in this manner.**

higher for bones plated with four screws than with five or more. Only two transverse fractures in this study were plated with four hole plates (Figure 4). The remaining twenty fractures were plated using five and six hole plates depending on the amount of comminution and obliquity.

Early range of motion is a theoretical advantage of rigid internal fixation. Although patients in this study averaged postoperative long arm immobilization for 5.7 weeks, motion was excellent or good in all cases. Several large studies (3, 7, 12, 31) have shown no increase in complications with ear-

ly motion begun after a seven to ten day period of soft tissue healing. Grace and Eversmann have shown the particular importance of early motion in open fractures and both-bone fractures. Unrestricted activity is generally allowed at three months (31).

Muller recommends plate removal after 1.5 — 2.0 years to allow the bone to return to normal architecture. Because of the difference in the modulus of elasticity, the plate and screws act as stress risers with potential for fracture. In our nine year follow-up, we have found only one patient symptomatic that could be attributed to the presence of plate and screws. This includes those with plates in place (Figure 8), and those with plates removed — all of which were asymptomatic and removed routinely. Although some authors recommend routine removal (12, 22, 23), the experience of others has not found this necessary (3, 27, 30, 31).

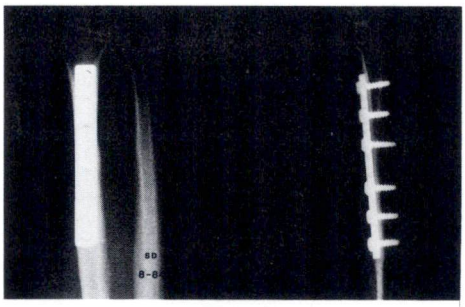


**FIGURE 8**

**Ten year follow-up of a 29 year old construction worker whose plate remained asymptomatic despite performing heavy labor including operation of a jackhammer.**

## CONCLUSION

Our long term follow-up of this series along with a review of the literature leads us to the following:

1) Dynamic Compression Plate Fixation is an excellent method of treatment for diaphyseal forearm fractures.
2) A four-hole plate may be effective for transverse fractures, but a five or six-hole plate is required for significant comminution or obliquity.
3) Primary bone grafting with compression plating is effective for non-unions and comminution involving more than one-third the shaft circumference.
4) Postoperative immobilization, after an initial 7-10 day soft tissue healing period, is probably unnecessary.
5) Routine plate removal is probably unnecessary.

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# Fracture and Fracture Dislocation of the Fifth Carpometacarpal Joint

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**ABSTRACT:** During the past five years, twenty fractures and fracture dislocations of the fifth carpometacarpal joint were seen and treated with open reduction and internal fixation. A review of the literature suggests that a fracture of the fifth carpometacarpal joint is a rare injury. Presented is a review of the anatomy and the classification system currently available, as well as our approach to the diagnosis and treatment.

## INTRODUCTION

Fracture or fracture dislocation at the first carpometacarpal joint is a relatively common injury. This injury has been well described and has been classified by Green and O'Brien[1,2]. However, the incidence of fractures and fracture dislocations involving the fifth carpometacarpal joint is considerably less frequent. In the past five years, twenty cases of fracture or fracture dislocations involving the fifth carpometacarpal joint were treated at Wayne State University. In an attempt to classify these injuries according to Chmell, et al an additional category was incorporated[3].

The first case of a fracture dislocation resembling a Bennetts fracture appeared in the literature in 1945 by Clement[4]. The eponym of "Reverse Bennetts Fracture" was instituted by Sandzen in 1973 after his description of the unstable fifth metacarpal fracture[5]. Nalebuff described the mechanism of injury for volar ulnar and volar radial dislocation[6]. Lilling, Chmell et al, Fischer, and Dommisse have all developed the mechanisms of injury for dorsal dislocations.[3,4,7,8] This study was designed to evaluate the surgical results of twenty unstable fractures as well as to develop a rational approach to an uncommon problem.

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## ANATOMY

The base of the fifth metacarpal rests on the ulnar half of the hamate. Because of the shallow nature of this saddle joint, the fifth carpometacarpal joint enjoys a 30° arc of rotation. This joint also articulates with the base of the fourth metacarpal. With this joint, the ulnar two metacarpals glide har-

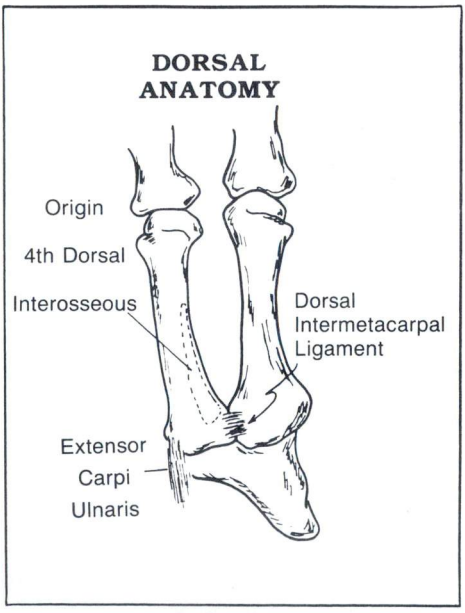


**FIGURE 1**

**The dorsal anatomy of the fifth carpometacarpal joint demonstrates the location of the fourth dorsal interosseous muscle and the dorsal intermetacarpal ligament. These two structures hold the fracture fragment in place while the pull of the Extensor Carpi Ulnaris pulls the shaft of the fifth metacarpal proximally.**

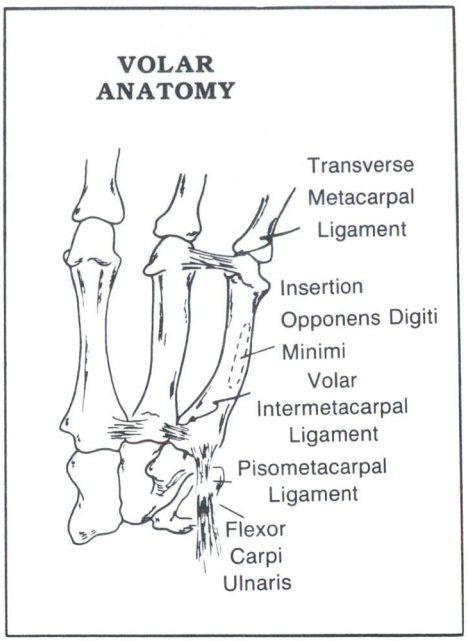


**FIGURE 2**

**This diagram illustrates the volar intermetacarpal ligament which also aids in stabilizing any fracture fragments. The pull of the Flexor Carpi Ulnaris through the pisometacarpal ligament will add to the distracting force acting on the metacarpal shaft. Because of the tension applied through the Transverse Metacarpal Ligament, Ulnar displacement occurs at the fracture site.**

moniously in rotation, to elevate the hypothenar eminence during power grip.[4,9,10]

Ligamentous support of the fifth carpometacarpal joint consists of volar and dorsal intermetacarpal ligaments, volar and dorsal carpometacarpal ligaments, as well as the pisometacarpal ligament (fig. 1 & 2).[3,6,8] Following fracture of the fifth metacarpal base, the radial portion of the metacarpal is rigidly stabilized by the carpometacarpal and intermetacarpal ligaments. The ulnar and proximal displacement of the metacarpal shaft which takes place is largely due to the pull of the Extensor Carpi Ulnaris and to a lesser degree by the Flexor Carpi Ulnaris through its insertion into the pisometacarpal ligament.[3,4,6,8]

The hypothenar musculature become an angulating force to the distal metacarpal shaft. Due to ulnar pull of the hypothenar muscles on the proximal shaft, the distal portion of the metacarpal is displaced in the radial direction. In reviewing the mechanism of injury to each fracture type, it will become important to note the ligamentous structures involved in producing each deformity.

## MECHANISM OF INJURY

**Type I** a dorsovolar crush injury: This injury is generated by a dorsalpalmar force directed to the ulnar border of the hand. The fracture becomes comminuted with minimal displacement (fig. 3 & 4). The metacarpal shaft does not migrate, however the articular surface may require stabilization. The two injuries seen in this group came as a result of punch press accidents.

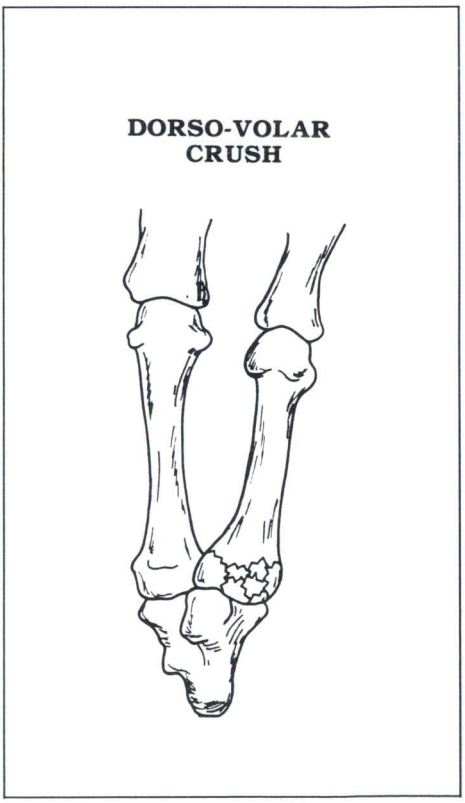


**FIGURE 3**

**The Dorso-Volar Crush injury generates a comminuted non-displaced fracture at the base of the fifth metacarpal. The comminuted pieces may require stabilization to maintain a congruent articular surface. In this series, the mechanism of injury involved punch press injuries.**

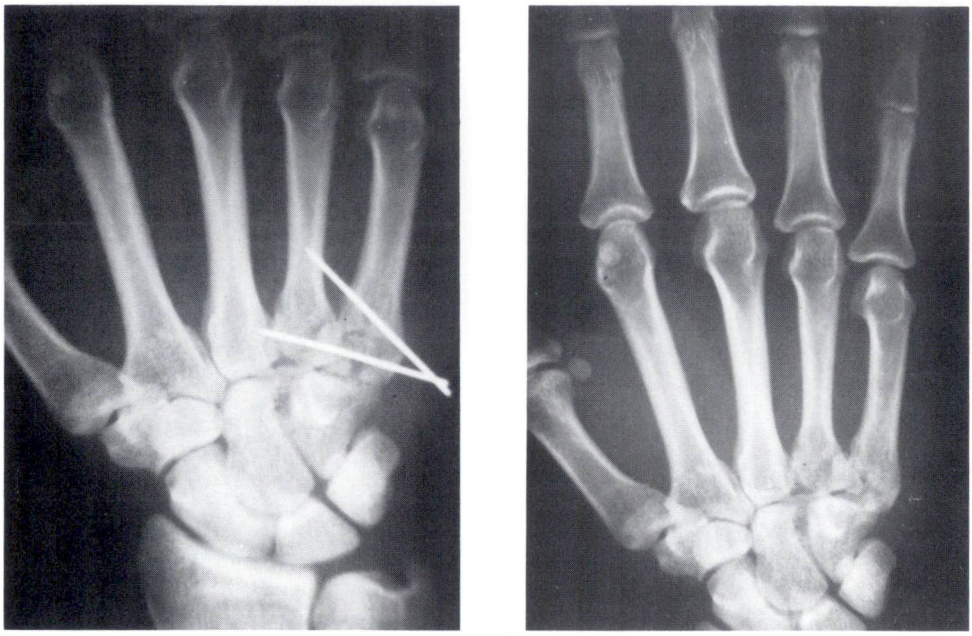

**FIGURE 4**

**This x-ray demonstrates a Type I Dorso-Volar Crush injury. This came as a result of a punch press injury and required open reduction and internal fixation for stability.**

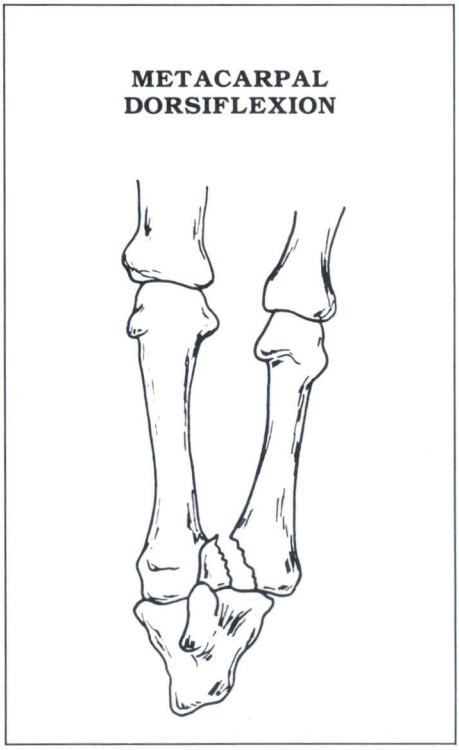


**FIGURE 5**

**This diagram illustrates a Type II Metacarpal Dorsiflexion Injury. These injuries can occur by a poorly placed Karate chop or by forces generated along the ulnar side of the hand as in a fall on the outstretched hand.**

**Type II,** a metacarpal dorsiflexion injury: Eight patients sustained acute dorsiflexon injuries with resulted in

**FIGURE 6**

**This type II injury generates shortening of the metacarpal shaft with displacement of the fracture fragment. Treatment is aimed at maintaining metacarpal height.**

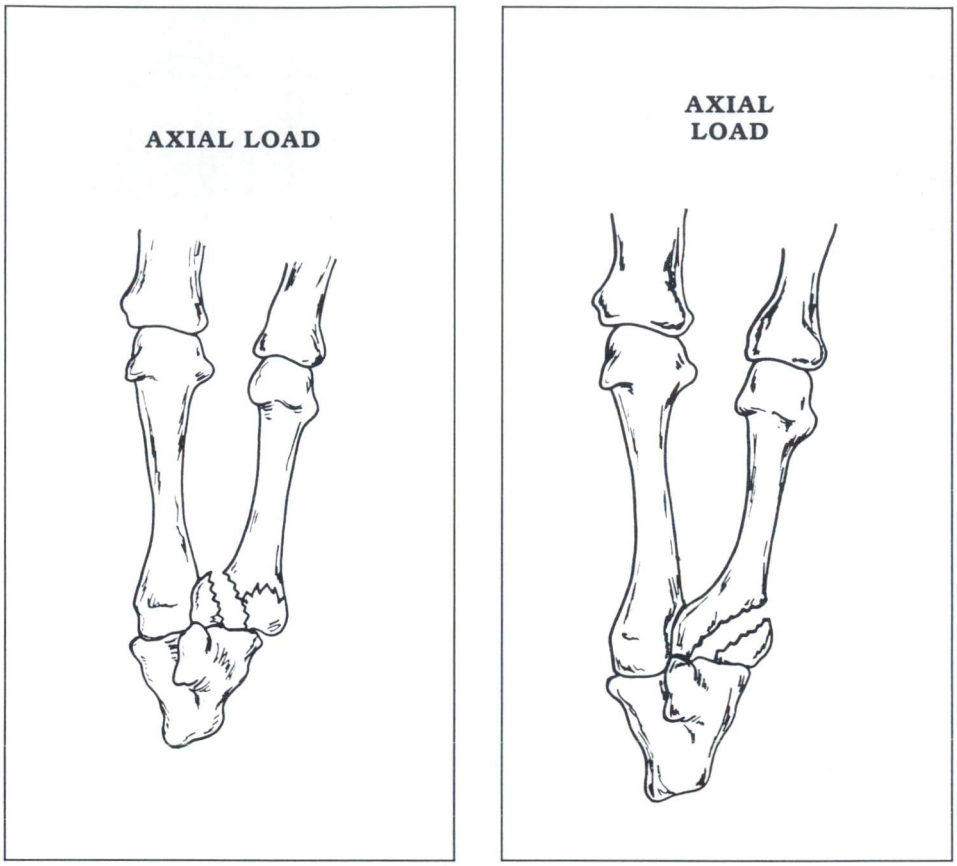


**FIGURE 7**

**Type III; Axial Load Injuries are usually caused when a clenched fist strikes an inanimate object. This injury can cause either the "Y" type fracture or the ulnar based fragment.**

bipartate fractures or fracture dislocations. An indirect lever strain is generated when the patient falls on the outstretched hand and lands on the ulnar border. A direct strain can be encountered with a poorly executed karate chop or when shielding against a night stick blow (fig. 5 & 6). In either type of injury, the metacarpal shaft is pulled proximally through the pull of the Extensor Carpi Ulnaris and Pisometacarpal ligaments. The radial fragment is stabilized by the intermetacarpal and carpometacarpal ligaments, as well as the fourth palmar interosseous muscle.[3,8,11]

**Type III,** an axial loading injury: Four patients were seen who had become angry to the point of punching a fixed inanimate object. For this reason, this type of fracture has become known as the "Fracture of Frustration." When a vertical load is generated along the shaft of the fifth metacarpal a "Y" type fracture or fracture dislocation is produced. The displacement of the metacarpal shaft occurs in a similar fashion to that of type II injuries (fig. 7 & 8).[3,8]

**Type IV,** a metacarpal flexion injury: Six patients were seen who had sustained a fracture of the hamate with concomittent dorsal dislocation of the fifth metacarpal. These injuries occurred when the back of the wrist was suddenly thrust into a flexed position. Most of the injuries occurred as a result of fighting, however one patient sustained this injury when he hit the back of his hand against the steering wheel during a motor vehicle accident (fig. 9 & 10). It should be noted, that the "Fleck" fracture commonly seen on the lateral view may be a Type IV fracture dislocation. This can be confirmed on the AP view when using the "parallel M" sign.

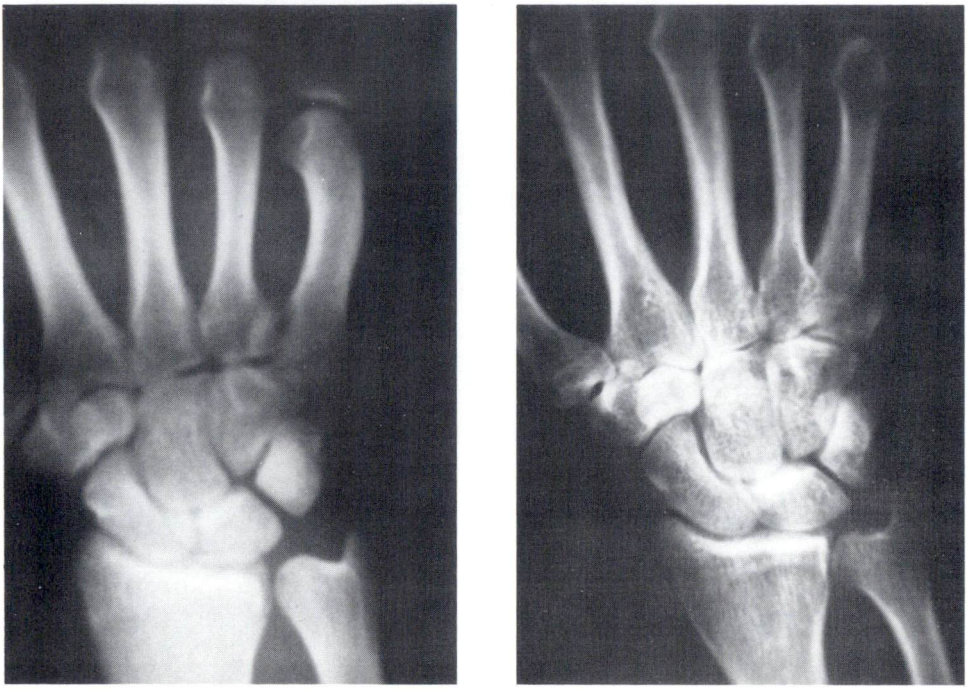

**FIGURE 8**

**Type III injuries generate either the "Y" or the ulnar fragment type fractures. Again K-wires are placed to hold the metacarpal shaft out to length and to maintain the articular surface.**

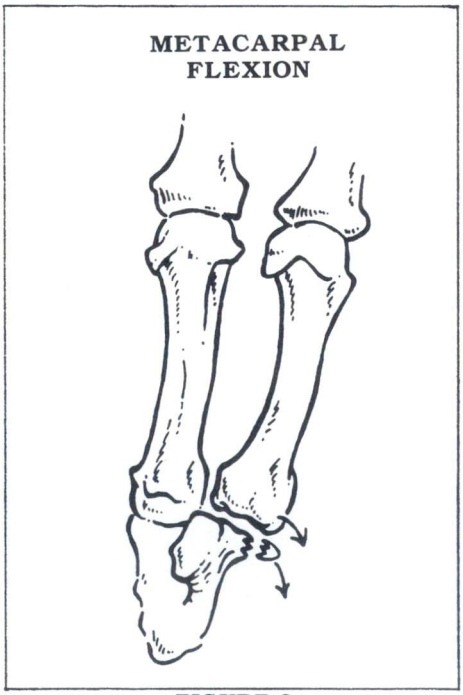


**FIGURE 9**

**Type IV Metacarpal Flexion Injuries: Occur when the wrist is suddenly forced into a flexed position. A fracture of the hamate occurs with associated dorsal dislocation of the fifth metacarpal.**

## DIAGNOSIS

With most patients presenting initially to the emergency room or family physician, the two most common x-ray views obtained will be the A-P Lateral views of the injured hand. Bora and Didizian have described a view in which the hand is positioned with 30° of pronation from the A-P plane (fig. 11).[12] This view highlights the fifth carpometacarpal joint quite nicely. If there is any question of fracture, subluxation, or dislocation of the fifth carpometacarpal joint, this view will provide the necessary exposure.

Also when examining a routine A-P film there are several things to consider. Fischer et al, has described the "Parallel M Sign" which is described as the product of parallel articular surfaces at the carpometacarpal joints (fig. 12).[7] It is known that the joint margins of opposing carpometacarpal joints are less than 2mm and that they will remain parallel to each other. As the A-P film is scanned, the opposing surfaces take on a parallel M configuration. Any disruption in this configura-

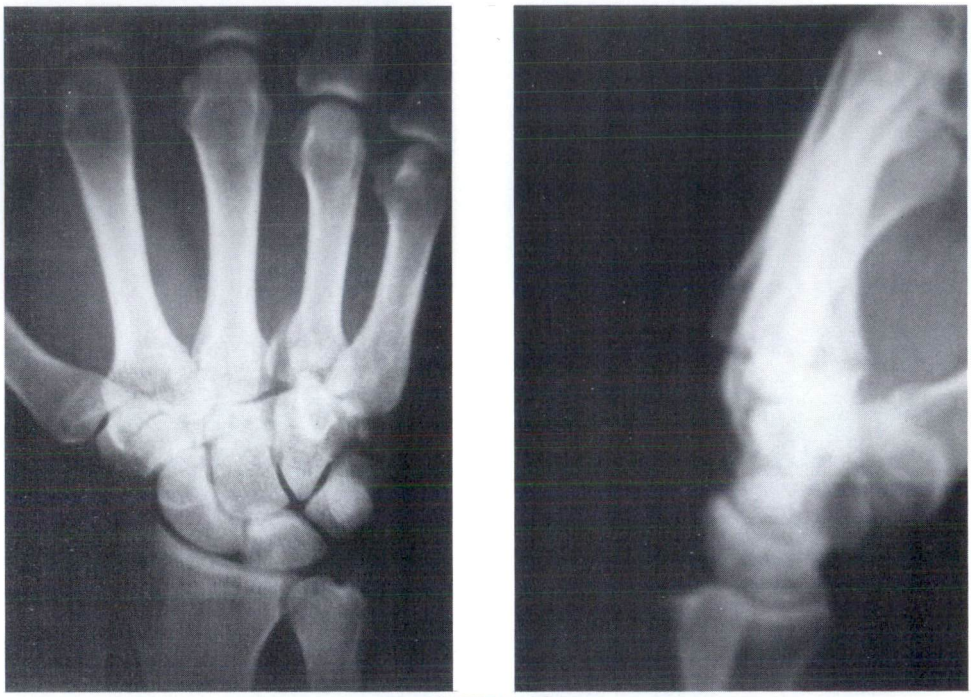

**FIGURE 10**

**This patient struck the back of his hand against the steering wheel during an auto accident and generated this Type IV fracture dislocation.**

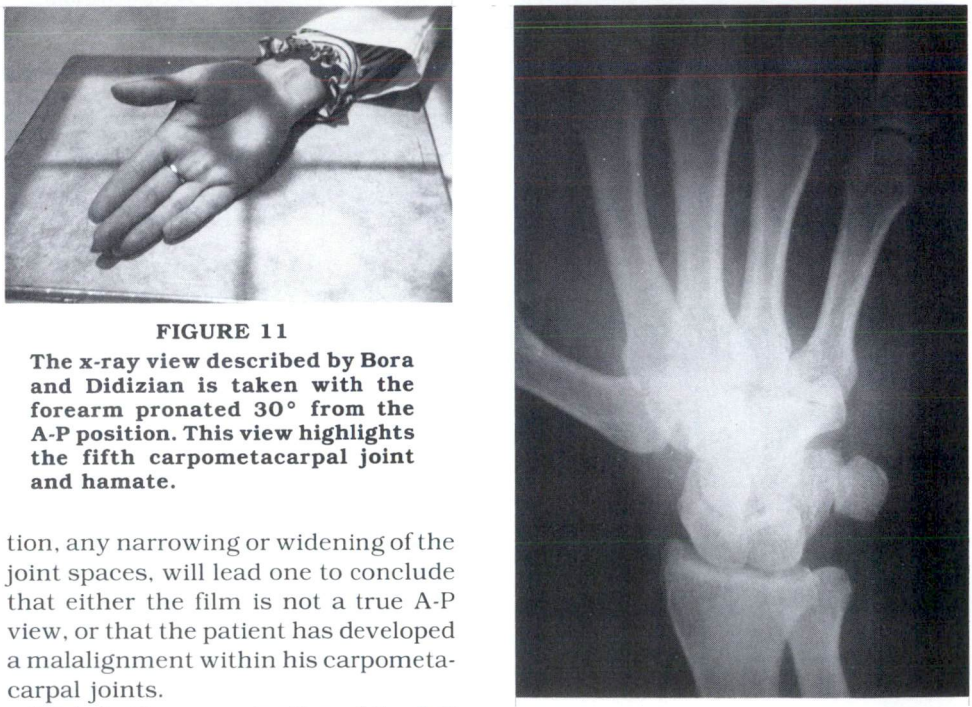

**FIGURE 11**

**The x-ray view described by Bora and Didizian is taken with the forearm pronated 30° from the A-P position. This view highlights the fifth carpometacarpal joint and hamate.**

tion, any narrowing or widening of the joint spaces, will lead one to conclude that either the film is not a true A-P view, or that the patient has developed a malalignment within his carpometacarpal joints.

With further examination of the A-P and oblique views Chmell et al, have discovered and described what they call the "Oblique Metacarpal Line" (fig. 13).[3] With the aid of this line any shortening of the fifth metacarpal shaft becomes more readily apparent. The line is drawn from the tip of the third metacarpal head through the tip of the fourth metacarpal head. If the fifth metacarpal head is in its normal position, the oblique metacarpal line should pass through the tip of this

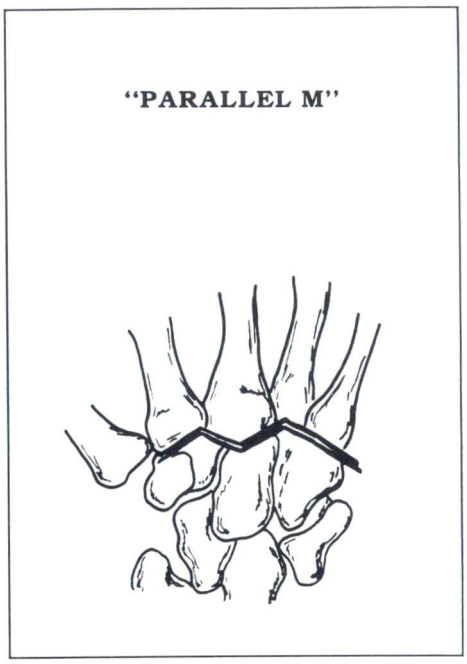


**FIGURE 12**

**The "Parallel M Sign" by Fischer, et al. deliniates the normal articular relationships of the carpometacarpal joints. When looking at the A-P view these relationships may uncover a subtle dislocation.**

metacarpal as well. It is recommended to x-ray the contralateral hand if there is any question of individual variability or of a fracture.

## TREATMENT

Closed reduction with casting has been espoused as a satisfactory approach to the stable fracture.[3,12,13] Nalebuff and Hsu have elaborated on the necessity of maintaining metacarpal length and joint surface congruity. Without the proper metacarpal length, the grip strength can drastically be reduced by an inadvertant lengthening of the intrinsics as well as the extrinsic flexor tendons.[3] Articular surface congruincy has also been established as preventing or at least prolonging the development of carpometacarpal joint arthritis which will also lead to a painful grip and loss of grip strength.

Chmell et al, have mentioned that the type I fracture has minimal displacement and for that reason can be treated with closed reduction and casting.[3] Our decision to surgically treat these twenty fractures was made with the understanding that anatomic reductions held with k-wire fixation would maintain an articular surface while instituting early range of motion, as well as hold the metacarpal shaft out to length. This would effect a more predictable result and will minimize

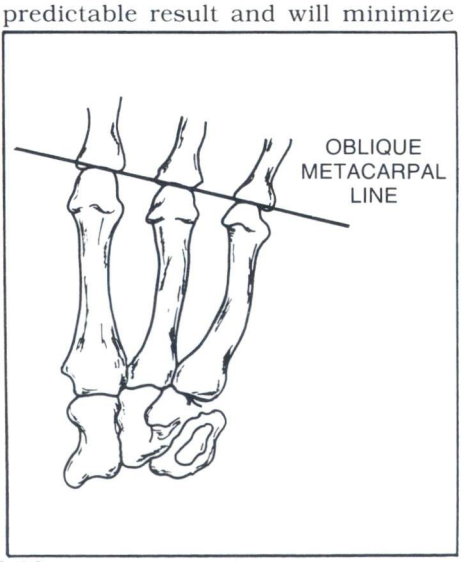


**FIGURE 13**

**The "Oblique Metacarpal Line" by Chmell et al., can also be utilized to diagnosis significant metacarpal shortening which can aid in determining the indicated form of treatment. In this x-ray 4mm of metacarpal shortening is seen which contributed to the decision for pinning this patients fracture.**

the incidence of loss of motion and grip strength.

As Nalebuff has pointed out, there are several approaches to the treatment of these fractures.[6] Closed reduction and casting is always an option especially in stable fractures. Closed reduction and percutaneous pin fixation is available for dislocations or simple fracture dislocations. Open reduction and k-wire fixation is certainly a reasonable approach to the complex or comminuted fracture. In this series of 20 cases, there was an average follow up of 26 months. The final dynamometer readings gave an average grip strength of 95% that of the normal side.

## SUMMARY

The successful treatment of intra-articular fractures or fracture dislocations of the fifth carpometacarpal joint begin with the proper diagnosis. There are three vital films to obtain in examining a patient for fractures around the fifth carpometacarpal joint. The A-P Lateral, and 30° Pronation view of Bora.[12] Four types of fractures have been described. In reviewing the A-P film, the "Oblique Metacarpal Line," and the "Parallel M Sign" are important in discovering a shift in the articular surface of the fifth metacarpal or shortening of the metacarpal shaft. In reviewing the lateral film, the "Fleck" fracture which is commonly seen and attributed to a triquetrial fracture or fracture of the hamate, can now be suspect of involving a possible fifth carpometacarpal dislocation.

When the proper diagnosis is made, treatment should be aimed towards providing a smooth articular surface for the carpometacarpal joint as well as maintaining metacarpal length. This in turn will minimize arthritic changes at the joint and will allow for a proper balance of tendon forces along the ulnar side of the hand.

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# Methicillin-Resistant Staphylococcus Aureus of the Hand: A Case Report

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**ABSTRACT:** It has become apparent that Methicillin-Resistant Staphylococcus Aureus infections are increasing in their appearance as both hospital and community acquired infections. This case report serves to illustrate that community acquired infections are now invading the general population and are no longer confined to the drug abusers and debilitated patients.

Strains of Methicillin Resistant Staphylococcus Aureus (MRSA) have been observed in Europe over the past twenty years as a cause of nosocomial infections.[1] Recently the emergence of MRSA has been described as occurring with increasing frequency in large referral hospitals affiliated with medical schools.[1,2] Our institution, a community teaching hospital of approximately 300 beds, has over the past 2-3 years, noticed an increasing prevelance of MRSA infections whose origin appears to be that of the chronic debilitated patient.

More recently the isolation of MRSA has increased so much that one may conclude it is now endemic to our institution. To confound the issue, we are now seeing MRSA strains from the community as well. The following case presentation is of a MRSA infection involving a hospital employee. The etiology of the infection could not be directly traced to the hospital where she works. Therefore, the authors believe this to be a community acquired infection.

## CASE REPORT

K.A. is a 25 year old nurse who began experiencing severe pain and swelling in her right finger on 1-28-84. Within 24 hours the swelling, which had begun in the hyponychium, continued to spread involving the DIP and PIP joints. A bleb formed over the eponychium (Fig. 1) and was associated with severe pain and erythema. At this point the patient presented herself to the emergency room of the hospital where she worked.

**FIGURE 1**

**This picture was taken at the time of surgery and demonstrates the aggressive behavior of the infection. Note that the bullous formation at the eponychium will damage the nail bed and the swelling extends to the PIP joint.**

The patient was treated in the emergency room by lancing the bleb, obtaining cultures and prescribing an oral cephalosporin. After an additional 24 hours the wound became more aggressive requiring hospitalization and the institution of Nafcillin 1.5 grams every four hours. The patient was taken to surgery on 2-1-84 for a thourough irrigation and debridement, and to obtain tissue cultures.

The tissue cultures indicated that this was a MRSA infection Sensitivities demonstrated that the organism was

sensitive to Vancomycin. The patient then received 5 days of IV Vancomycin at 1 gram every 12 hours, and was followed with Septra DS for an additional 5 days.

In reviewing the patients history, evidence did exist that she had participated in the care of a MRSA patient 2 weeks prior to the onset of her symptoms. However, a more direct cause seemed to be the fact that she had been scraping and varnishing her furniture the day before the infection developed. In so doing, she had inadvertantly lacerated the fat pad of her right index finger in several places.

At three months followup, the skin had healed without a blemish and the nail, which had been removed at the time of surgery, was growing back with a moderate amount of irregularity. The PIP and DIP joints demonstrated a full range of active and passive motion. Two point discrimination at the fingertip was 3mm.

## DISCUSSION

Epidemiological reports have demonstrated that in 85% of the hospitals in which MRSA infections have been introduced, they have become endemic.[3] The reports by Saravolatz and Levine have shown that MRSA infections have become endemic in Detroit not only as hospital acquired infections but also as community acquired infections. However, these reports have shown the population at risk to be in drug abusers and debilitated patients.[3,4,5] These epidemiological reports have also demonstrated that carrier states exist. These carriers can be hospital employees who have culture positive MRSA organisms growing on their hands or in their nostrils.[3]

As a community hospital in a northwestern suburb of Detroit, we are now faced with the problem of dealing with community acquired MRSA infections in the healthy sector of our population. This becomes clinically relevant when treating infections of the staphylococcal etiology. The physician is now challenged not only with the Penicillin Resistant Staphylococcus Aureus organisms but also the Methicillin Resistant Staphylococcus Aureus organisms. When faced with an aggressive superficial or systemic staphlyococcal infection, the physician must be cognizant of the Methicillin Resistant Staphylococcus Aureus organism as a possible etiological factor in the patients morbidity. As contained within this report, the drug of choice is Vancomycin.

In reviewing the literature, it has become apparent that the Methicillin Resistant Staphylococcus Aureus organism is increasing in its appearance in both the hospital and community. It is no longer just confined to the debilitated nursing home patient nor the drug abuse population. This report was developed to illustrate the need of considering MRSA in the differential for resistant infections, in a population group that was previously not considered to be at risk.

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# Glomus Tumors of the Upper Extremity

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**ABSTRACT:** Twelve patients with glomus tumors of the upper extremity were treated between 1973 and 1983. The glomus tumor represents a benign neoplasm of the elements composing a glomus body. Glomus bodies are located in the dermis and are thought to be involved in temperature regulation. The tumor typically produces pain, tenderness, and temperature intolerance. Physical signs are usually not apparent and diagnosis, therefore, depends upon suspicion. The lesion most commonly occurs in the hand, particularly the subungual area, and excision almost always offers permanent relief. Recurrence and sarcomatous changes are rare.

## INTRODUCTION

The glomus body is a structural unit consisting of an innervated arteriovenous anastomosis. It is located in the reticular layer of the dermis (Figure 1) and its function appears to be related to control of skin circulation.[1] It has not been shown, however, to have any primary function as a central regulator of body temperature.[2] Glomus bodies are located throughout the body with the highest concentrations found in the subungual area (Figure 2).

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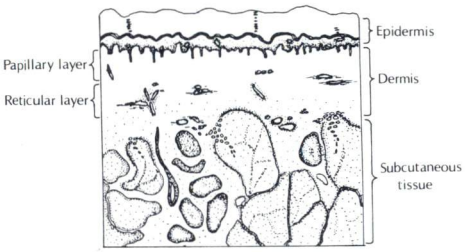


**FIGURE 1**

**Skin of the Hand. Glomus bodies are located in the Reticular Layer of the Dermis.**

Developmentally, glomus bodies appear several months after birth and gradually atrophy during late adult

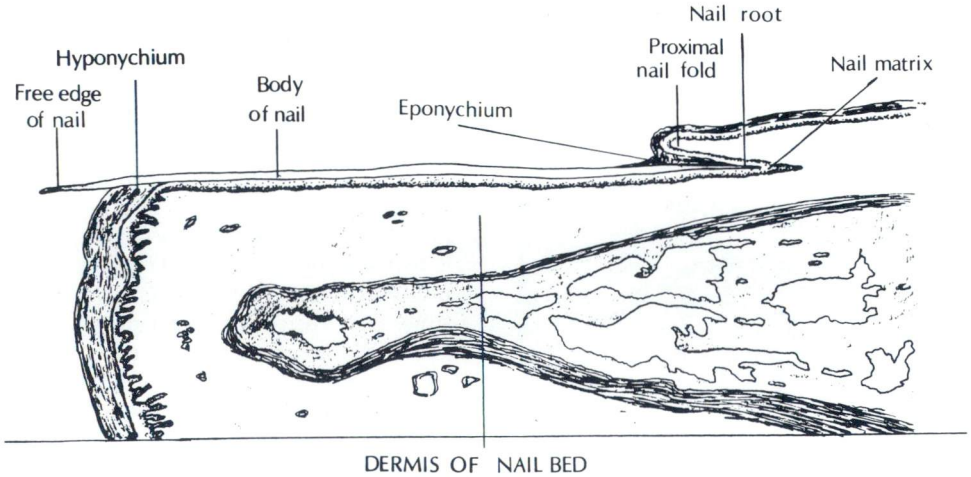


**FIGURE 2**

**Fingertip. Most commonly, glomus tumors are found beneath the fingernail in the dermis of the nail bed.**

life.[3] As originally described by Masson in 1924,[4] a glomus body begins with afferent arterioles which originate from dermal arteries and, in turn, branch into several canals (Figure 3). The canal is lined by endothelial cells and surrounded by muscular fibers and nerves. Scattered throughout the muscle fibers are the rounded, epithelial-like "glomus" cells (Figure 4). The canals then drain into collecting veins. Collagenous tissue surrounds the entire glomic complex.

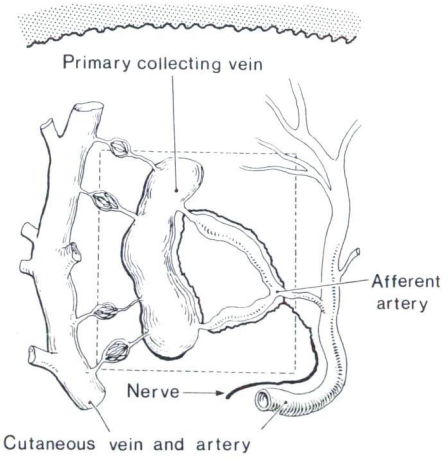


**FIGURE 3**

**The Glomus Body: Afferent arterioles originate from dermal arteries and branch into several canals. These canals are lined by nervous tissue, muscular fibers and epithelial-appearing "glomus" cells. These neuro-myo-arterial elements compose the glomus body and are thought to have a thermo-regulatory function.**

**Redrawn from Carroll & Berman, Glomus Tumors of the Hand; JBJS 54-A: 691-703 1972.**

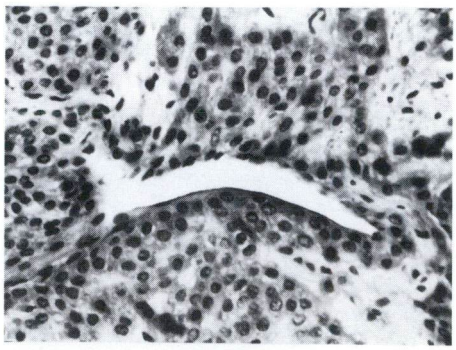

**FIGURE 4**

**Glomus Tumor: A flattened vascular space is seen exhibiting a cuff of cells with rounded configurations. The cells contain a single round bland nucleus.**

Ultrastructurally, the glomus cell typically is rounded or polygonal, 8-12 um in size, and has a rounded nucleus with occasional clefts and prominent nucleoli.[5] The cytoplasm is most noted for its bundles of thin actin-like filaments. Being closely spaced the cells frequently interdigitate with each other along short, knobby processes.

The glomus tumor was first described by Wood[6] in 1812 as a painful subcutaneous nodule. Koaczek[7] in 1878 noted its subungual location, and Giossev[8] in 1902 associated it with an arteriovenous anastomosis that occurs in man and many mammals, but not in reptiles. This suggested a possible role in temperature regulation. Masson in 1924 was the first to fully describe the tumor, suggesting that it represented, essentially, a hematoma, with hypertrophy or overgrowth of the normal structures. He appreciated its neuro-myo-arterial elements, and termed the lesion a "glomus" (Latin for "ball") tumor. Popoff[9] added further to the understanding of its function, correlating the anatomy with the temperature regulatory function in 1934.

More recently, however, the glomus tumor has been identified as predominantly a neoplasm of the modified, smooth muscle cells of the normal glomus body.[5] Smooth muscle cells and glomus cells appear to be interrelated, with both possibly arising from pericytes.

## MATERIAL AND METHODS

We report twelve patients with histologically confirmed glomus tumors of the upper extremity treated over a ten-year period from 1973 to 1983. In all cases, treatment was by resection. All patients were contacted by phone for follow-up and were re-examined if any residual deformity or recurrence of symptoms was noted. The symptoms, physical findings, and medical and surgical histories were reviewed, and are summarized in Table 1. The average age at the time of surgery was 35.7 years (range 17 to 73 years) with the distribution as shown in Figure 5. Average follow-up was 2.7 years (range 2 months to 10 years). The ratio of females to males was 3:1, as was the ratio of white to black patients.

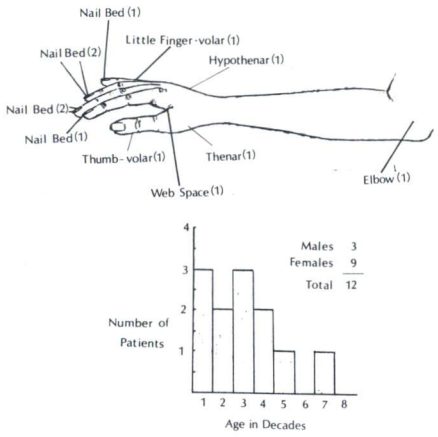


**FIGURE 5**
**Age, Sex, Location.**

The average duration of symptoms was 4.2 years, with a range of 3 months to 20 years.

## RESULTS

In 50 percent of the cases, the glomus tumor was located deep to the nailbed beneath the fingernail. The remaining lesions were distributed throughout the upper extremity, as noted in Figure 5. Both the left extremity and the non-dominant hand were affected twice as often. A history of trauma was associated with one-third of the lesions (Patients 2, 4, 7, and 8).

Presenting symptoms consisted of pain with pressure in 12/12 patients, pain without pressure in 10/12, cold intolerance in 9/12, and nocuturnal pain in 3/12.

No correlation was found with prior medical or surgical history, except in Patient 8, who had undergone excision of a foreign body and neuroma before developing a glomus tumor.

All patients but one presented with extreme tenderness to pressure which was pinpoint. The exception was a mass which was only mildly tender and was removed primarily for cosmetic reasons.

Roentgenograms at the time of diagnosis revealed erosive changes in only one patient; this defect filled in within 6 months of resection.

On gross examination, the average tumor size was 3.8 mm. at its widest margin. Nearly all of the tumors were well-circumscribed and easily removed. No problems with hemostasis were encountered.

All but one patient had immediate, permanent relief of pain following resection. Patient 7 re-developed occasional mild to moderate discomfort at the site of previous resection in the proximal nail bed after 10 years of complete relief of symptoms. The recurrent symptoms were much milder.

In patients with subungual tumors, pain was naturally present after removal of the nail, but all patients described the pain as "different" and much improved. The nail grew out and remained split or ridged in three of the six patients with subungual tumors.

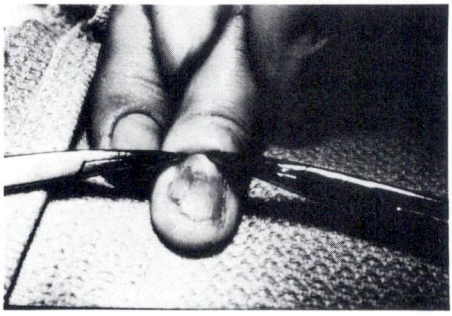

**FIGURE 6a**
**Glomus Tumor located in proximal aspect of nail bed.**

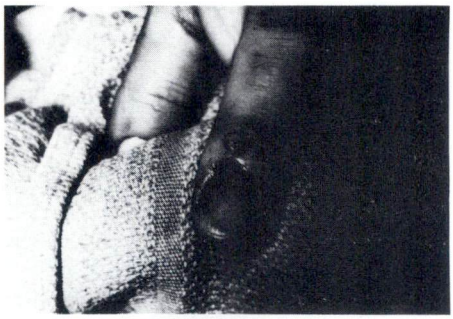

**FIGURE 6b**
**Tumor Resected.**

## DISCUSSION

The incidence of glomus tumors in relation to all hand tumors is reported at 1 to 4.5 percent.[2,10,11,12,13] At the Massachusetts General Hospital, glomus tumors occurred once in 4,500 (0.02 percent) tumors of all types.[1] Although no multiple sites were noted in this series, reports of incidence of such glomus lesions has been reported at 23 to 25 percent in adults[14,15] and 26 percent in children.[16]

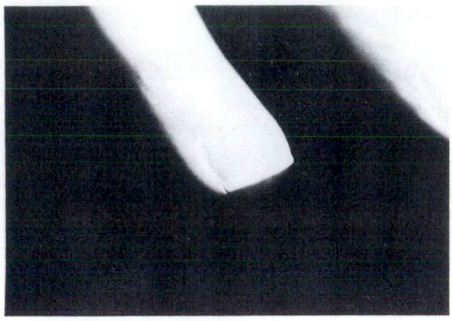

**FIGURE 7**
**Residual ridging of nail after excision of subungual glomus tumor.**

The classic triad of pain, tenderness, and cold intolerance was present in 75 percent of our patients. However, as is most often the case with glomus tumors, the duration of symptoms was quite long before the diagnosis was considered (average 4.2 years), with one woman experiencing pain for 20 years. The most common physical sign, bluish discoloration beneath the skin or nail, occurred in less than half of the cases reported here (5/12). A provocative test using ethyl chloride spray over the involved area may be used to reproduce the cold intolerance, thereby establishing early diagnosis.[3]

The exact relationship of trauma to glomus tumors has not been established. Antecedent incidents have been reported in 10 to 38 percent of cases in the literature.[1,13,17] In our series, one-third of the lesions occurred in patients with known histories of trauma.

Although only one of our twelve patients demonstrated bony erosion, incidences ranging from 22 to 60 percent have been reported elsewhere.[13,17] In our patient, the defect completely filled in within 6 months of tumor excision.

Grossly, the glomus tumor consists of a bluish-red nodule located in the dermis. Excision is simple and usually affords permanent relief. Figures 6A and B demonstrate a tumor resected from the proximal aspect of a nail bed. In 3 of 6 cases involving subungual lesions, residual ridges occurred in the nail (Figure 7). Figure 8A shows an unusual location in the hypothenar eminence. En bloc excision involving the surrounding tissue was performed (Figure 8B).

Although excision is usually definitive treatment in patients with glomus tumors, recurrence has been reported, with incidences ranging from 12.5 to 18 percent.[1,13] In this study, one patient had recurrent symptoms after 10 years of relief. Maxwell[15] has suggested that recurrence may be due to multiple-site tumors with inadequate excision.

Sarcomatous progression of glomus tumors are quite rare. No such changes were noted in our patients. In one series of several hundred glomus tumors reported by the Armed Forces Institute of Pathology, only four cases of glomangiosarcoma were identified.[5] Histologically, all of the sarcomatous areas were located in areas of benign glomus tumors and no metastases were noted. Treatment of these lesions consisted of complete excision.

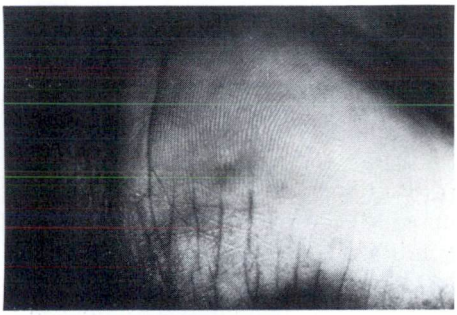

**FIGURE 8a**
**Tumor in hypothenar emminence.**

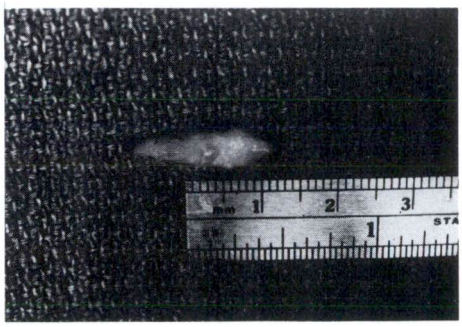

**FIGURE 8b**
**En bloc excision.**

## CONCLUSION

The glomus tumor represents a benign neoplasm of the elements composing a glomus body. It typically produces pain, tenderness, and temperature intolerance. Physical signs are usually not apparent and diagnosis, therefore, depends upon suspicion.

**TABLE 1 — SUMMARY OF CLINICAL MATERIAL**

| CASE # | PATIENT | AGE | SEX | RACE | DURATION OF SYMPTOMS (YEARS) | SIDE | LOCATION | BONE CHANGES | RESULTS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AF | 17 | F | W | 3.0 | L | Ring finger nailbed | — | Mild nail deformity | |
| 2 | KP | 27 | M | B | 0.3 | R | Index finger nailbed | — | Resolved | Laceration 2 mos. prior to symptoms |
| 3 | GH | 17 | M | B | 1.0 | L | Thumb-index web space | | Resolved | |
| 4 | EH | 49 | F | W | 2.5 | L | Elbow | — | Resolved | Blunt trauma |
| 5 | LE | 23 | F | W | 0.5 | R | Middle finger nailbed | — | Mild nail deformity | |
| 6 | AG | 37 | M | W | 2.0 | L | Thumb | — | Resolved | |
| 7 | FD | 41 | F | W | 10.0 | R | Ring finger nailbed | + | Pain re-curred after 10 yrs.; nail deformity | Crush injury |
| 8 | GR | 34 | F | W | 8.0 | L | Little finger nailbed | — | Resolved | Laceration prior excision of foreign body and neuroma |
| 9 | GB | 59 | F | B | 1.0 | L | Hypothenar eminence | — | Resolved | |
| 10 | CM | 18 | F | W | 0.3 | L | Thenar area | — | Resolved | |
| 11 | AG | 73 | F | W | 20.0 | R | Little finger | — | Resolved | |
| 12 | MD | 33 | F | W | 1.5 | L | Middle nailbed | | Resolved | |

Location most commonly is in the hand, particularly the subungual area, and excision is curative. Recurrence and sarcomatous changes are rare.

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# The Incidence of Idiopathic Scoliosis in a North American Black Population

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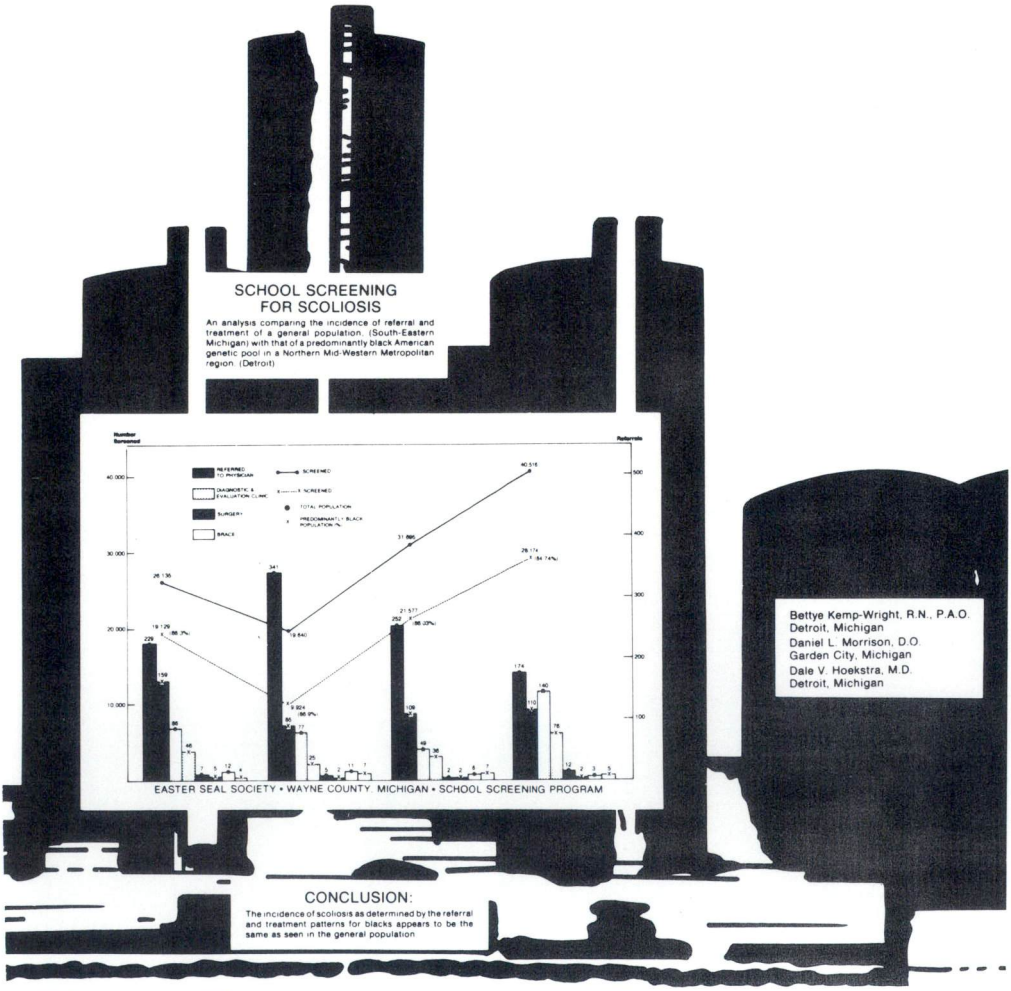
The purpose of this exhibit is to review the results of a school screening program composed of an 80% black population. During the four year period of this study, 92,033 students were primary screened. Of those patients referred for tertiary evaluation, X-ray examinations were performed on all patients who demonstrated clinical findings of scoliosis by physician evaluation. Patients with curvatures measuring less than ten degrees were managed by referral for re-screening the following year. The patients with scoliotic deformities measuring ten degrees or more were diagnosed as having scoliosis and were treated by follow-up observation, bracing, cutaneous electrical stimulation or surgery. Statistical analysis of this data revealed no statistically significant differences in the incidence of scoliosis between blacks and whites.




**This poster exhibit was presented at the Nineteenth Annual Scoliosis Research Society Meeting, September 19-22, 1984; Orlando, Florida.**