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Below the abstract provide three to ten key words or short phrases that will assist indexers in cross indexing your article. Use terms from the medical subject heading list from the Index Medicus whenever possible.

Introduction
Acquaint the readers with the problem and quote the most pertinent papers. Mention clearly the nature and purpose of the work. The work to be published should strictly have more than two years follow-up.

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Explain clearly yet concisely your clinical, technical or experimental procedures. Previously published methods should be cited only in appropriate references.

Results
Describe your findings without comment. Include a concise textual description of the data presented in Tables, Charts and Figures.

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Comment on your results and relate them to those of other authors. Define their significance for experimental research or clinical practice. Arguments must be well founded.

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Use only those distinct illustrations that clarify and increase the understanding of the text. All illustrations must be numbered and cited in the text. If possible send black and white glossy print photographs the colour photos taken may be sent to my e-mail address with permission to make black and white prints from it.

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Type legends for each illustration.

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- An Alternative Method of Fixation
Surgical Review Exposures for Primary Total Knee Arthroplasty Current Concepts

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ABSTRACT

TKR is one of the greatest inventions of the last century and is one of the widely accepted and successful surgeries in modern orthopaedics. The most important step in primary TKR is the correct approach and correct incision, which does not affect the vascularity of the flaps. Anterior midline incision with medial parapatellar capsular approach is the most widely accepted method. But this may weaken the medial soft tissue structures. The incision should not be lateral to the lateral margin of the patella. Undermining of the skin is dangerous and heavy retraction affects the vascularity of the flaps. Interrupted loose sutures are used to close the wounds. In subvastus approach, the vastus medialis is separated and retracted from the capsule. But the exposure is less extensive, when compared to the medial parapatellar approach. But the medial soft tissue structures are not weakened. In midvastus approach, the vastus medialis is split at the superomedial corner. In this, exposure is better and this approach is becoming more popular now. Patella eversion is easier and exposure is adequate. Majority of the valgus knees can be operated through medial parapatellar capsular approach, but in severe valgus deformity, a lateral capsular approach is
used. Care should be taken to avoid the avulsion of the tibial tubercle, which is a disastrous complication. In stiff knees without any range of movements, extensile approach with quadriceps v-y plasty, or a rectus snuff is used.

**SKIN INCISION**

The anterior midline is the most commonly used one. It can be just lateral to the anterior midline but never be medial to it because majority of the blood vessels to the flaps come from the medial side. The incision should never be lateral to the lateral margin of the patella.

The incision of any previous surgeries around the knee should be always taken into account. Never undermine the skin, always raise fasciocutaneous flaps. There is no role for minimally invasive approach, use a liberal incision and avoid heavy retraction which will definitely delay wound healing. In nutshell the best incision is midline anterior approach with a starting point 7 cm superior to the proximal pole of patella, the distal end point being 6 cm distal to the inferior pole of the patella. During closure it is better to use interrupted mono filament suture material for the skin with the knots tied loosely (2).
CAPSULAR APPROACHES

**Medial parapatellar approach:** Compared to any approach gives maximum exposure for bone cuts, ligament balancing and prosthesis fitting. Fig1.

The medial approach is started at the medial 1/3rd of the patellar tendon 3 cm above the superior pole of patella, curves round the medial aspect of patella with at least 1 cm of the medial retinaculum attached to the patella for facilitating late repair. The approach ends 1 cm medial to the tibial tubercle.
Fig 2 The release of medial structures

Patella is then dislocated laterally with the knee flexed; the patella should not be everted forcefully because avulsion of the ligamentum patellae from the tibial tubercle could be a disastrous complication. This risk should be reduced by division of patellar ligament, with a piece of bone at the tibial tuberosity and release of adhesions under the patellar tendon and the quadriceps tendon. Closure is made by interrupted sutures applied loosely so that flexion is not restricted. Fig 2.

**Subvastus approach:** The medial margin of the vastus medialis is freed and retracted and the tendinous insertion of this muscle is separated from the medial capsule(5). The distal part of the approach is the same as that of the medial parapatellar approach. The vastus medialis, extensor mechanism and the patella are retracted laterally and then the patella is dislocated laterally. Muscle need not be retracted. Advantage of this approach is that extensor mechanism as such is minimally disturbed, the tracking of the patella is not affected and the blood supply to the patella is preserved. Scarring patellar fixity, severe flexion deformity and previous surgery are however contraindications.

**Midvastus approach:** The vastus medialis muscle is split at the superomedial corner of the patella(2). Distal part of the approach is the same as medial parapatellar approach. Split in the muscles needs only few sutures for approximation.
Compared to the subvastus approach the patellar eversion is easier, the blood supply to the patella is unaffected, and the extensor mechanism is least disturbed. Contraindications are the same as that of subvastus approach.

**Lateral approach:** This is used in valgus knees. Upper part of the anterior compartment muscles and ITB are elevated(4,5). Popliteus tendon may be released, lateral patellar retinaculum is incised and patella everted medially. Care should be taken to avoid avulsion of the ligamentum patellae from the tibial tubercle, which is a catastrophic complication. Main advantage is that this approach helps in lateral release in valgus knees. (4)

**Midline approach:** Capsular incision starts at the middle of the quadriceps tendon. The distal part of the approach is the same as that of medial parapatellar approach. This is not routinely used nowadays.

**Extensile approach:** When patellar eversion is difficult in stiff knees and patellar fixity is there, extensile approach is needed. Tibial tubercle division, quadriceps V-Y plasty, rectus snip and medial epicondyle osteotomies are used. Rectus snip involves medial parapatellar approach and cutting either transversely or of obliquely the rectus tendon and then followed by inferolateral eversion of the patella

Quadriceps V-Y plasty helps in lengthening of the quadriceps tendon and this during surgery helps in the turning down the patella inferolaterally
The medial epicondylar osteotomy is done through medial parapatellar approach with an osteotome from distal to proximal 1 cm thick bone is elevated, the attachment of the collaterals and the adductors should not be disturbed; the elevated bone piece is fixed with screws.

Another method is to skeletonise the femur by subperiosteally elevating the muscles and the ligaments. One should be careful not to produce mediolateral instability. (5)

Author’s own preferred method is to use medial parapatellar approach in both varus and valgus knees (6)

**CONCLUSION**

Instability after TKA is the most distressing biologic complication for the patient and it reduces the confidence of the patient. Correct and perfect approach will help in along way to prevent this complication.

**REFERENCES:**


Surgical Management of Congenital Scoliosis

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Chang-Gung memorial Hospital, Taiwan

INTRODUCTION

Congenital scoliosis is a developmental growth tethering of the vertebral column. It differs from idiopathic scoliosis in associated anomalies, progression and treatment. Each case of congenital scoliosis must be individualized as the decision making and surgical treatment can be difficult in congenital scoliosis. The age of the child, associated conditions, general health of the child, and the behavior of the curve all should be assessed for proper management. Patients who have congenital scoliosis have high frequency of associated anomalies, both within and out side the spine, which makes thorough evaluation essential. The natural history ranges from no progression or clinical symptoms to extremely severe deformity, pulmonary compromise, early death, or paraplegia. The challenge to medical profession is to prevent these dire
problems from ever occurring. Bracing is useless in congenital scoliosis with a short stiff curve pattern. Bracing can be useful for scoliosis with a long and flexible curve pattern. There is no justification for allowing the congenital curve to progress relentlessly in mistaken belief that trunk height should increase before correcting or arresting the curve. In situ fusion, vertebrectomy, osteotomy etc can be used judiciously (13). The goal of the present study are to analyze surgically treated cases of congenital scoliosis at Chang-Gung Memorial Hospital, Linkou, Taiwan over a period of 19.5 yrs from 1983 July onwards.

**MATERIALS AND METHODS**

We reviewed 42 consecutive cases of congenital scoliosis from 1983 July to 2001 Jan (17.5 yrs) with minimum 2 yrs follow up post surgery. In our study group 27 were females and 15 males with male to female ratio of 1 : 1.8. Average follow up was 13.65 yrs. We assessed the patients clinically and radiographically. The curves were measured independently using cobb’s method by three of the authors independently. The curves are assessed at 1st visit, pre-op, bending, post-op, and at the final follow up. Renal ultrasound/ IVP are done to those being advised by the nephrologist. Pulmonary functions are assessed for those with severe thoracic curves. 10 of our patients underwent anterior and posterior fusion rest posterior fusion alone, except one who underwent subcutaneous roding. 35 patients underwent instrumentation and the rest 7 un-instrumented (body cast after surgery) 2 patients with hemi vertebrae alone at the lower lumbar level underwent de-cancellation through posterior approach.
Others with possible correction and fusion. 7 patients had to undergo second surgery for various reasons.

RESULTS

14 patients had associated kyphosis. We could not elicit any history of parental consanguinity or family history of similar illness. The mean age of presentation was < 5 yrs. Five of the patient’s birthdays are not known.

17 of our patients had hemi vertebra and un segmented bar as the most common anomaly. Then followed hemi vertebra alone in 12 cases, un segmented bar alone in 8 cases and mixed in 5 cases.

Table I: Patterns of spinal anomaly

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemi vertebra + Unsegmented bar</td>
<td>18</td>
</tr>
<tr>
<td>Hemi vertebra alone</td>
<td>12</td>
</tr>
<tr>
<td>Un segmented bar alone</td>
<td>8</td>
</tr>
<tr>
<td>Mixed</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
</tr>
</tbody>
</table>

The anomalies were located in the thoracic vertebrae in 26 cases and 10 in lumbar.
Table II: Level of spinal anomaly

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic (T1-T9)</td>
<td>14</td>
</tr>
<tr>
<td>Thoraco-lumbar (T10-L2)</td>
<td>23</td>
</tr>
<tr>
<td>Lumbar (L3-L5)</td>
<td>5</td>
</tr>
</tbody>
</table>

The maximum numbers of anomalies were around the thoraco lumbar junction. In the lumbar area the most number of anomalies were at L3 (5 cases).

Table III: Associated anomalies

<table>
<thead>
<tr>
<th>Associated anomaly</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>4</td>
</tr>
<tr>
<td>Hand</td>
<td>3</td>
</tr>
<tr>
<td>Cleft palate</td>
<td>1</td>
</tr>
<tr>
<td>Arthrogryposis</td>
<td>1</td>
</tr>
<tr>
<td>Imperforated anus</td>
<td>1</td>
</tr>
<tr>
<td>Syringomyelia</td>
<td>1</td>
</tr>
</tbody>
</table>

Associated anomalies

13 of our study group had associated anomalies.
1. Imperforate anus and poly dactyly (left thumb).
2. Congenital heart disease
   - VSD and left thumb hypoplasia
   - Tetrology of Fallot
   - Mitral regurgitation
3. Cleft palate
4. Fused carpal bones
   - Left capitate and hamate
5. Fused rib T12 and T13
6. Arthrogryposis and left arm malformation
7. Ehler Danlos Syndrome
8. Syringomyelia
9. Mental retardation and unsteady gait
10. Branchial cleft fistula

The curves ranged from 25-103 degrees in the coronal plane. Majority of the curves were in the 31-60 range. The curves addressed include smaller ones, which are treated prophylactically owing to their bad prognosis and larger
curves which presented late. Kyphosis ranged from – 40 to 105 degrees.

35 of our patients underwent instrumented fusion, (except one with subcutaneous rodding). The rest 7 were given body cast following surgery. 3 of them maintained correction after fusion. One progressed rapidly needing instrumentation for maintaining balance. It progressed from 52-86 degrees without instrumentation. After 2nd surgery the curve was corrected to 80 degrees (anterior and posterior surgery and TSRH). 2 of the rest developed kyphosis (59-105) and one progressed a little and then stabilized.

Graph I: Age at surgery
Table IV: Factors associated with a poor result

<table>
<thead>
<tr>
<th></th>
<th>Good (32)</th>
<th>Poor (9)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>13.1 yrs</td>
<td>7.8 yrs</td>
<td>0.01</td>
</tr>
<tr>
<td>Cobb's angle</td>
<td>60.8°</td>
<td>55.3°</td>
<td>0.41</td>
</tr>
<tr>
<td>Posterior fusion alone</td>
<td>24 (32)</td>
<td>5 (9)</td>
<td>0.26</td>
</tr>
<tr>
<td>Kyphosis (+)</td>
<td>9 (32)</td>
<td>4 (9)</td>
<td>0.35</td>
</tr>
<tr>
<td>Instrument (-)</td>
<td>4 (32)</td>
<td>2 (9)</td>
<td>0.44</td>
</tr>
<tr>
<td>Sex M/F</td>
<td>12/20</td>
<td>2/7</td>
<td>0.34</td>
</tr>
<tr>
<td>F/u duration</td>
<td>54 mo</td>
<td>76 mo</td>
<td>0.33</td>
</tr>
</tbody>
</table>

4 patients who underwent posterior surgery alone developed crankshaft phenomenon. The criteria to detect crank shaft phenomenon was increase in Cobb’s angle >10 degrees of the post operative measurement at last follow up, coronal balance change of > 2.5 cm or trunk shift change of > 1 cm.
Table V:

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemi vertebra</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Un segmented bar</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Hemi + Un seg</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Mixed</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Table VI: Nature of anomaly patterns

<table>
<thead>
<tr>
<th></th>
<th>Age at operation</th>
<th>Cobb's angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemi vertebra</td>
<td>13.8 yrs</td>
<td>47.8°</td>
</tr>
<tr>
<td>Un segmented bar</td>
<td>11.2 yrs</td>
<td>61.9°</td>
</tr>
<tr>
<td>Hemi + Unseg</td>
<td>10.8 yrs</td>
<td>59.3°</td>
</tr>
</tbody>
</table>
COMPLICATIONS

1. Pseudarthrosis-7 patients
2. Seven patients developed kyphosis.
3. One patient developed lumbar kyphoscoliosis after correction of thoracic lordoscoliosis. It needed re-operation from T2-L5.
4. Wound infection in 2 cases.
5. Adjacent instability in one case.
6. Crank shaft in 4 patients.

DISCUSSION

The patients in our study group presented mostly in the early growth spurt or in the adolescent growth spurt. Also a combination of hemi vertebrae and unsegmented bar was the most common anomaly in our series. The next was hemi vertebrae alone. Mc Master in his series has reported unilateral unsegmented bar as the most common anomaly, followed by hemi-vertebrae. Study of congenital scoliosis by Hossain Shah cheraghi et. al, Iran (4) report hemi-vertebrae as the most frequent anomaly.

The anomalies were more around the thoraco-lumbar junction.
Most of the reported series have tethered cord as the most common associated intraspinal anomaly. John. R. Prashinski et. al., (Washington) in 30 cases of congenital anomalies of spine showed 30% intraspinal anomalies with 5 tethered cord (conus at or below mid L2 body) and 4 syringomyelia. J.F. Sarwark (5) in 40 cases of congenital spinal anomalies reported 12 patients with tethered cord of the 13 who had associated intraspinal anomalies. In contrast, we encountered congenital heart disease as the most frequent anomaly (4 cases) among the 13 who had associated anomalies. In our patients, only one had associated intraspinal anomaly (syringomyelia). Also none of our patients developed neurological deficit post operatively.

The largest curves that crossed 100 degrees are that of unsegmented bar and hemi-vertebra combination. The second largest curves were for unsegmented bar which range from 70-90 degrees. Then, hemi vertebrae depending on its number and location. Mixed pattern.

Those patients who underwent anterior and posterior surgery and instrumentation had good correction even from 80 to 24 degrees with good balance. Of the 32 patients who underwent posterior surgery alone, 4 of them developed crankshaft phenomenon. It did not develop in any of the 10 cases that underwent combined surgery, even though most of the patients fall under the similar age group and similar magnitude of curve at presentation. Even with the largest magnitude curves in the combined surgery group; crank shaft phenomenon did not develop. This is contrary to the
observation by Kimberly and Lonstein in the paper presented at 2001 SRS annual meeting stating that the only factor that affected crank shaft phenomenon was curve magnitude at the time of surgery. Because different variables are present, we can’t pin point the cause of crankshaft phenomenon in our study. But the age at surgery and the curve magnitude did not contribute. Curves more than 45 degrees who underwent anterior and posterior fusion did not develop crankshaft phenomenon.

Also even when combined surgery is done and implants are not used, the curves tend to progress and needed instrumentation later for balance. So implants should be used for maintaining correction till the fusion is solid.

CONCLUSIONS

As congenital scoliosis is developmental growth tethering of the vertebral column, earlier the treatment, better the results. It is always better to have a short balanced spine than crooked short spine. (there is no growth potential in the areas of unsegmentation. The side opposite a hemi vertebra is lacking corresponding growth plates). In most of these cases associated anomalies of the spinal cord are common as the neural column and the vertebral column develop together. In our study group the presence of intraspinal anomaly was only one in comparison to many other studies who report intraspinal anomaly (tethered cord) as the most common associated anomaly. We have congenital heart disease as the most common.
As expected the age of presentation peaked the early growth spurt and the adolescent growth spurt. Also in our study group the anomalies of the vertebrae are mostly a combination of hemivertebrae and unsegmented bar which are different from other studies. We suggest combined anterior and posterior surgery for curves more than 45 degrees in young children and instrumented to maintain the curve. The magnitude of the curve at surgery did not contribute to the development of crank shaft phenomenon.

**KEY POINTS**

Congenital scoliosis/ crank shaft phenomenon/intra spinal anomalies/type of vertebral anomalies/combined surgery/age of presentation/instrumentation.

**REFERENCES**


Physiological Distraction in the Management of Malunited Fractures of Distal Radius

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Investigation performed at Department of Orthopaedics, Medical College Hospital, Kottayam, Kerala, India; after
obtaining clearance from the Institutional review board/ethical committee.

KEY WORDS:
1. Physiological distraction
2. Malunited distal radius fracture
3. Maluniting distal radius fracture
4. Mini distractor
5. Callotasis/Callotaxis

ABSTRACT
35 patients with malunited symptomatic fracture of distal radius with an average radial shortening of 2mm, presenting after a minimum of two months of treatment were subjected to a new method of correction of malunion, in a prospective study done between February 2002 and August 2004. We are proposing a novel method of physiological distraction of the malunion using a simple mini distractor; applying the principle of Callotasis. The patients were followed for an average of 24 months following distraction. The indications for the procedure were pain and functional limitations rather than the degree of anatomical deformity. Sixteen patients were men and nineteen were women; their average age was forty three years (range, twenty two to sixty-four years).

Preoperative radiographs revealed an average ulnar inclination of 14 degrees, an average radial shortening of 2 millimeters, and an average dorsal inclination of 24 degrees. Flexion of the wrist averaged 24 degrees; extension of the wrist, 35 degrees; supination of the forearm, 41 degrees; and
pronation of the forearm, 54 degrees. The average grip strength was around 40% in comparison with the normal hand. At an average of 24 months (range, 22 to 31 months) after the procedure, supination of the forearm had improved to an average of 77 degrees and pronation had improved to an average of 75 degrees (p < 0.05 for both). Flexion of the wrist had improved to an average of 55 degrees, extension improved to an average of 65 degrees and grip strength had improved to 75% in comparison with the contralateral hand (p < 0.05 for both). Dorsal inclination averaged 0 degrees; radial lengthening 9 millimeters; and ulnar inclination, 22 degrees. The functional result was rated as very good in 22 patients, good in eight, fair in three and poor in two.

The initial results of the study are very encouraging and we have been able to correct deformities presenting to us even up to four months after the original injury. This study has broken the myth that a rigid callus or bony union forms by the end of the conventional period of immobilisation for 6 – 8 weeks; since distraction of the deformity at the original fracture site is possible, even after this period leading to deformity correction and symptomatic relief.

We therefore present this as a landmark study in the treatment of malunited distal radius fractures in an adult.

BACKGROUND
Malunited fractures of distal radius are very common in our day to day practice; which may be due to inadequate immobilisation, improper reduction or inability to maintain the
reduction as a result of severe comminution often seen in these types of fractures. These observations lead to hypothesize that the fractures might have actually required a much longer period of immobilisation than the currently accepted protocol. If this is true, such fractures, especially those in their early period of malunion, might not have been malunited by now, but could be in their ‘maluniting’ phase. Moreover the callous might not have consolidated and might still be exhibiting the property of biological plasticity and should be amenable to distraction and deformity correction. These patients present to us either with simple cosmetic deformity or with varying degrees of functional disability (Fig 1a, b, c, d). The common treatment option is corrective osteotomy which is a major surgical undertaking, very often requiring a second surgery for implant removal.

**Fig. 1a : Deformity and ulnar styloid prominence**

**Fig. 1(b): Pre-op radiograph (Lat. View) (c) Pre-op radiograph (AP view)**
Malunion following a volarly/dorsally displaced fracture of the distal metaphysis of the radius with/without comminution and with/without an intraarticular component impairs the normal function of the radiocarpal and distal radioulnar joints. Shortening of the radius relative to the distal end of the ulna following a collapse, which is very common; combined with a pronation/supination deformity of the distal fragment, invariably results in incongruence and instability of the distal radioulnar joint. Such deformity adversely affects rotation of the forearm. In addition, an increase in the dorsal/volar inclination of the radiocarpal articular surface, combined with a loss of normal ulnar inclination in the frontal plane, causes a decrease in grip strength, a decrease in extension, flexion, radial and ulnar deviation of the hand and wrist, and a cosmetic deformity.

Although there is considerable information in the literature regarding the indications for, and the techniques and results of, corrective osteotomy for the treatment of malunited, dorsally displaced fractures of the distal end of the radius, there have not been any reports concerning treatment of dorsally/volarly displaced malunions of the distal end of the radius without osteotomy. In the current study, we evaluated the
results of physiological distraction of the malunion using a simple mini distractor; applying the principle of Callotasis in the management of malunited fractures of distal radius with radial shortening, in thirty-five patients.

MATERIALS AND METHODS

This study was conducted in the Department of Orthopaedics, Medical College, Kottayam for a period of two and a half years. 35 patients with malunited symptomatic fracture of distal radius with an average radial shortening of 5mm, presenting after a minimum of two months of treatment were subjected to a new method of correction of malunion, in a prospective study done between February 2002 and August 2004. There were 16 male and 19 female patients. Fracture occurred in right wrist in 21 patients, left wrist in 14 patients. The injury was caused by a simple fall in 46% (16), fall from a height 43% (15) and Road accident 11% (4). The outcome of therapy with a novel method of physiological distraction of the malunion using a simple mini distractor; applying the principle of Callotasis was studied on this case series. The patients were followed for an average of 24 months following distraction. The average age was of patients included in the study group was forty three years (range, twenty two to sixty-four years). All patients had been managed initially at other institutions and later were referred to us because of a residual deformity.

The indications for physiological distraction were pain or functional limitations along with varying degrees of
anatomical deformity. The preoperative functional problems included painful or limited supination/pronation of the forearm, loss of extension/flexion of the wrist due to radial shortening, dorsal displacement of the distal radial fragment, and loss of grip strength that adversely affected the patient’s capacity to return to his or her preinjury occupation.

**The criteria for exclusion**

1. The criteria for exclusion from the study included:

2. Fractures over 4 months duration;

3. Function that was acceptable to the individual despite deformity;

4. Dorsal angulation of the distal radial fragment above 10 degrees;

5. Children below 17 years;

6. Pregnant women;

7. Fractures with local/systemic infection;

8. Non-cooperative patient;

9. Advanced osteoarthrotic changes in the radiocarpal joint; and

10. Severe osteoporosis.

Cases with dorsal angulation exceeding 10° were managed with a dorsal distractor to achieve correction; however these cases were not included in this study. Neither advanced age nor osteoarthrotic changes in the distal radioulnar joint were considered contraindications to the fractional distraction of the malunion.

The injuries leading to the malunion included an unstable, dorsally displaced extra-articular fracture that...
had collapsed leading to radial shortening while the limb was immobilized in a cast in twenty nine patients; extra-articular, volarly displaced fracture of the distal end of the radius (a Smith fracture) in three patients (deformity in all three being within the limits of inclusion criteria); and a dorsally displaced metaphyseal fracture of the distal end of the radius with an intra-articular extension in another three patients.

The initial treatment had consisted of closed reduction and immobilization in a cast for thirty two patients. The remaining three patients had had operative intervention before referral: two had had external fixation (for ligamentotaxis), and one had had closed reduction, percutaneous placement of smooth Kirschner wires. The patients were referred to us an average of 2 ½ months (range, one to four months) after the fracture. All thirty-five patients reported pain in the wrist. Pain in both the radiocarpal and the radioulnar joint was evaluated. Pain was assigned 1 point if it was severe (occurring during activities of daily living or during rest), 2 points if it was moderate (occurring during activities requiring forceful grip), and 3 points if it was mild (occurring only at the extremes of motion but not interfering with function); 4 points was assigned if there was no pain. Three patients reported no pain; eleven, mild pain; and twenty one, moderate pain in the radiocarpal joint. Five patients reported no pain; eleven, mild pain; eight, moderate pain; and eleven, severe pain in the distal radioulnar joint.
All thirty-five patients had limited motion of the wrist as measured with a standard goniometer. Extension averaged 35 degrees compared with 69 degrees for the contralateral wrist, and flexion averaged 24 degrees compared with 69 degrees for the contralateral wrist. Supination of the forearm averaged 41 degrees, 46 degrees less than that on the contralateral side, and pronation averaged 54 degrees, 30 degrees less than that on the contralateral side.

The average preoperative grip strength was measured with a sphygmomanometer cuff. The cuff was inflated to 30mm of mercury pressure and the patient was asked to grip it with maximum force. The elevation in the reading was noted and graded in comparison with the normal hand as a percentage.
sagittal plane and a line drawn parallel to the shaft of the radius. Ulnar inclination averaged 14 degrees (range, -15 degrees to 32 degrees); radial shortening, two millimeters (range, -1 to 4 millimeters); and dorsal inclination, 24 degrees (range, 15 to 40 degrees).

**OPERATIVE TECHNIQUE**

Pre-operative planning: The goals of physiological distraction of the malunion using a simple mini distractor include restoration of the radial shortening, restoration of the anatomical relationship of the distal radioulnar joint, anatomical restoration of the distal radial articular surface if possible, to establish a more normal distribution of load on the radiocarpal joint and improvement of the range of motion of the radiocarpal joint.

**Procedure:** It is a minor surgical procedure, done on an outpatient basis, under local anaesthesia (Fig. 2a, b, c). Patient is allowed to go home on the same day after one to two hours of observation. After taking proper aseptic precautions, patient is draped and given local anaesthesia. Once the desired effect of local anaesthesia is confirmed, under image intensifier guidance, one or two Schanz pins (1.8mm or 2mm diameter; depending on the size of the malunited distal fragment) are placed in the malunited distal fragment, parallel to each other (if two pins are being used). The pin placement is made after creating a stab incision on dorso-lateral aspect of the distal radius, and visualizing the bone surface so as to avoid any soft tissue damage while drilling in the Schanz pins. Two Schanz pins (2.5mm diameter) are
placed in the shaft of radius proximal to the site of malunion, as close to the distal pin(s) as possible and in alignment with them. These pins are connected together with a mini distractor. Patient is observed for 1 to 2 hours after the procedure and is allowed to go home with prophylactic antibiotic, analgesic and antioedema measures. Pin tract site is dressed with povidone iodine gauze. The limb is kept elevated and active finger movements are started from day one. Reduction of fracture and position of the pins are confirmed by antero-posterior and lateral view x-rays of the wrist. Frequent active movements of fingers, wrist, elbow and shoulder are advised. Patients are also instructed to clean pin tracts twice daily using hydrogen peroxide and povidone iodine solution.

Postoperative Regimen and Evaluation: Distraction is initiated after 48 hours and at the rate of 0.17mm every 4 hours, after ensuring that patient has proper comprehension on the method of distraction. The distractor has a nut with 6 faces, sequentially numbered from 1 to 6 and one complete turn of the nut would produce a distraction equivalent to 1 mm. The patient is educated to turn the nut clockwise every 4th hour with minor adjustments permitted in time so as to not to disturb the patient’s normal sleep habits. Thus a 24 hour period would produce an effective distraction of 1mm. In other words, distraction would occur in a gradual and phased manner at the rate of 0.17mm every 4th hour. Hence it was termed as physiological (Fig. 3). The patient was also instructed on the importance of proper and meticulous pin site care.
and wrist joint mobilization exercises. Patient is reviewed every week and check radiographs are obtained in every visit and properly catalogued and carefully analyzed for the data (clinical and radiographic), starting from the second review. The patients were followed for an average of twenty-four months (range, twenty-two to thirty-one months) after the distraction. Consolidation of the callotasis site was documented at an average of eight weeks (range, six to ten weeks) post distraction. Mini-distractor was then removed depending on clinical and radiological assessment of fracture union. A plaster of Paris sugar tong slab is applied to the forearm for 4 weeks as a prophylactic measure to prevent future collapse.

**Fig. 3: Correction of malunion with result at 2 years follow up**
ANALYSIS OF CASES

Evaluation was based on subjective criteria, including pain in the radiocarpal or radioulnar joint, or both, as well as objective data, including the active range of motion of the wrist and forearm, grip strength as measured with a method similar to that used preoperatively, and ability to engage in the preinjury occupation.

Pain at each of the two articulations was evaluated postoperatively with use of the same system that had been used before the operation. Flexion-extension of the radiocarpal joint of at least 130 degrees was assigned 4 points; 101 to 129 degrees, 3 points; 80 to 100 degrees, 2 points; and less than 80 degrees, 1 point. Rotation of the forearm ranging from 160 to 180 degrees was assigned 4 points; 140 to 159 degrees, 3 points; 120 to 139 degrees, 2 points; and less than 120 degrees, 1 point. Grip strength that was at least 80 per cent of that of the uninvolved hand was assigned 4 points; 65 to 79 per cent, 3 points; 40 to 64 per cent, 2 points; and less than 40 per cent, 1 point. A total score of 18, 19, or 20 points was considered very good; 15, 16, or 17 points, good; 12, 13, or 14 points, fair; and 11 points or less, poor. The overall preoperative score averaged 11 points (range, 7 to 15 points). Twenty nine patients had a rating of poor; and six, fair.

Work capacity was evaluated according to whether or not the patient
was able to resume his or her preinjury occupation with or without restrictions.

Radiographs that had been made in the immediate preoperative period as well as those that had been made at the latest follow-up evaluation were used to assess osseous union, ulnar variance, ulnar inclination and volar inclination.

Paired t tests were used to evaluate the extent of improvement in the range of motion, grip strength, and overall score between the preoperative and latest postoperative evaluations. A p value of less than 0.05 was considered significant.

ANALYSIS OF FUNCTIONAL RESULTS

Modification of Demerit point system described by Gartland and Werley

<table>
<thead>
<tr>
<th>a. Residual deformity</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Prominent ulnar styloid</td>
<td>3</td>
</tr>
<tr>
<td>ii. Residual dorsal tilt</td>
<td>2</td>
</tr>
<tr>
<td>iii. Residual deviation of hand</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. Subjective Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Excellent - No pain, disability or limitation of motion</td>
</tr>
</tbody>
</table>

*Journal of the Kerala Orthopaedic Association Vol. 19, No. 1, August 2005*
ii. Good - mild (occurring only at the extremes of motion but not interfering with function) 3

iii. Fair - moderate (occurring during activities requiring a forceful grip) 2

iv. Poor - severe (occurring during activities of daily living or during rest) 1

c. Objective Evaluation

i. Flexion-extension of the radiocarpal joint

<table>
<thead>
<tr>
<th>Degree Range</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥130 degrees</td>
<td>4</td>
</tr>
<tr>
<td>101 to 129 degrees</td>
<td>3</td>
</tr>
<tr>
<td>80 to 100 degrees</td>
<td>2</td>
</tr>
<tr>
<td>≤ 79 degrees</td>
<td>1</td>
</tr>
</tbody>
</table>

ii. Rotation of the forearm

<table>
<thead>
<tr>
<th>Degree Range</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>160 - 180 degrees</td>
<td>4</td>
</tr>
<tr>
<td>140 to 159 degrees</td>
<td>3</td>
</tr>
<tr>
<td>120 to 139 degrees</td>
<td>2</td>
</tr>
<tr>
<td>≤ 119 degrees</td>
<td>1</td>
</tr>
</tbody>
</table>
iii. Grip Strength (expressed as percentage in comparison to that of uninvolved side)

<table>
<thead>
<tr>
<th>Percentage Range</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 80 %</td>
<td>4</td>
</tr>
<tr>
<td>65 % - 79 %</td>
<td>3</td>
</tr>
<tr>
<td>40 % - 64 %</td>
<td>2</td>
</tr>
<tr>
<td>≤ 39 %</td>
<td>1</td>
</tr>
</tbody>
</table>

d. End-Result Point Range

<table>
<thead>
<tr>
<th>Grade</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Excellent</td>
<td>18 – 20</td>
</tr>
<tr>
<td>ii. Good</td>
<td>15 – 17</td>
</tr>
<tr>
<td>iii. Fair</td>
<td>12 – 14</td>
</tr>
<tr>
<td>iv. Poor</td>
<td>&lt; 11</td>
</tr>
</tbody>
</table>

_Lidstrom and Frykman's grading of end result (Radiological)_

<table>
<thead>
<tr>
<th>Grade (No or insignificant deformity)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I (No or insignificant deformity)</td>
<td>Dorsal tilt not exceeding neutral, radial shortening less than 3 mm and articular step off 0-1 mm</td>
</tr>
<tr>
<td>Grade II (Slight deformity)</td>
<td>Dorsal tilt of 1 to 10 degrees, radial shortening 3 to 6 mm and articular step off 1-2</td>
</tr>
<tr>
<td>Grade III (Moderate deformity)</td>
<td>Dorsal tilt of 11 to 14 degrees, radial shortening of 7 to 11 mm and articular step-off 2-3 mm.</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Grade IV (Severe deformity)</td>
<td>Dorsal tilt of at least 15 degrees, radial shortening of minimum 12 mm or more and articular step-off &gt; 3 mm.</td>
</tr>
</tbody>
</table>
The patients were followed for an average of twenty-four months (range, twenty-two to thirty-one months) after the distraction. Consolidation of the callotasis site was documented at an average of eight weeks (range, six to ten weeks) post distraction.

At the latest follow-up examination, twenty-six patients were pain-free (Fig. 8). Of the remaining nine patients, four continued to note mild pain in the radiocarpal joint, six had mild pain in the distal radioulnar joint, and one had severe pain in that joint. Twenty-nine patients rated their working capacity to be equal to that before the fracture, and others noted some residual disturbance in the overall function of the wrist that necessitated modification of their occupation.

The average supination (Fig. 7) of the forearm improved from 41 degrees (range, 0 to 90 degrees) preoperatively to 77 degrees (range, 65 to 90 degrees) postoperatively (p < 0.05). Only three patients had supination of the forearm that was 70 degrees or less. The average pronation of the forearm was 75 degrees (range, 70 to 90 degrees) postoperatively, representing an 21-degree improvement compared with the preoperative average of 54 degrees (range, 0 to 90 degrees) (p < 0.05).

The average flexion of the wrist improved from 35 degrees (range, 0 to 60 degrees) preoperatively to 55 degrees (range, 50 to 75 degrees) postoperatively (p < 0.05). The average extension of the wrist was 65 degrees (range, 60 to 80 degrees) postoperatively, with the preoperative value of 24 degrees (range, 20 to 40 degrees) (Fig. 4).
The average grip strength also improved, from 40% of that of contralateral side preoperatively to 75% at the latest follow up (p < 0.05).

Many had reported a subjective improvement in pain, function and mobility (stiffness); some had disappearance of symptoms pertaining to reflex sympathetic dystrophy. This could probably be attributed to the increased local vascularity as a result of the callotasis. However, conclusive evidence to this effect will require a larger study group which includes more patients with such pathology.

The most recent radiographs revealed union at the site of the callotasis in all thirty-five patients (Fig. 5).
The average ulnar inclination was 22 degrees (range, 10 to 25 degrees) compared with 14 degrees (range, -2 to 20 degrees) preoperatively. Dorsal inclination improved to an average of 0 degrees (range, -4 to +4 degrees) compared with the preoperative value of -4 degrees (range, -10 to 0 degrees). Radial length averaged 9 millimeters (range, 7 to 11 millimeters) compared with the preoperative value of 2 millimeters (range, -1 to 4 mm) (Fig. 6).

The overall functional result (Fig. 9) was rated as very good in twenty two patients, good in eight, fair in three, and poor in two. Of the two patients who had a poor rating, one had residual pain in the distal radioulnar joint and the other had limitation of the range of motion of the wrist and forearm which was not satisfactory to the patient. The overall post
distraction score averaged 16 points (range, 11 to 20 points) compared with the preoperative average of 11 points (range, 7 to 15 points) (p < 0.05)

<table>
<thead>
<tr>
<th></th>
<th>Overall score</th>
<th>Range</th>
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<tbody>
<tr>
<td>Pre-op</td>
<td>11</td>
<td>7 - 15</td>
</tr>
<tr>
<td>Post-op</td>
<td>16</td>
<td>11 - 20</td>
</tr>
</tbody>
</table>

The anatomical end results according to modified Lidstrom and Frykman's grading is as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>No deformity</td>
<td>32</td>
</tr>
<tr>
<td>Grade II</td>
<td>Slight deformity</td>
<td>3</td>
</tr>
<tr>
<td>Grade III</td>
<td>Moderate deformity (not Nil</td>
<td></td>
</tr>
<tr>
<td>Grade IV</td>
<td>Severe deformity (not included in Nil</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 7: Comparison of function before and after physiological distraction

Fig. 8: Pain at two year follow up
**Fig. 9: Overall functional results as rated by the patients**

**STATISTICAL ANALYSIS**

This was a prospective case series study. Results were statistically analysed for significance using Paired T test. The articular step and range of movement, pre and postoperative were analysed.

35 patients had a mean Preoperative Supination of 41 degrees and Postoperative Supination of 77 degrees. On statistical analysis using paired T test, the values were found to be significant with degree of freedom of 34 and p value of < 0.0001.
35 patients had a mean Preoperative Pronation of 54 degrees and Postoperative Pronation of 75 degrees. On statistical analysis using paired T test, the values were found to be significant with degree of freedom of 34 and p value of < 0.0001
Paired Samples Correlations

<table>
<thead>
<tr>
<th>Pair</th>
<th>Pronation Pre &amp; Pronation Post</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pronation Pre &amp; Pronation Post</td>
<td>35</td>
<td>.411</td>
<td>.014</td>
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Paired Samples Test

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 Pronation Pre Pronation Post</td>
<td>20.97</td>
<td>22.11</td>
<td>3.74</td>
<td>-28.57 -13.38</td>
<td>-5.612</td>
<td>34</td>
<td>.000</td>
</tr>
</tbody>
</table>

Paired Samples Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 Extension pre</td>
<td>24.29</td>
<td>35</td>
<td>4.71</td>
<td>.80</td>
</tr>
<tr>
<td>1 Extension Post</td>
<td>65.23</td>
<td>35</td>
<td>5.29</td>
<td>.89</td>
</tr>
</tbody>
</table>

Paired Samples Correlations

<table>
<thead>
<tr>
<th>Pair</th>
<th>Extension pre &amp; Extension Post</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extension pre &amp; Extension Post</td>
<td>35</td>
<td>.241</td>
<td>.163</td>
</tr>
</tbody>
</table>

35 patients had a mean Preoperative Extension of 24 degrees and Postoperative Extension of 65 degrees. On statistical analysis using paired T test, the values were found to be significant with degree of freedom of 34 and p value of < 0.0001.
35 patients had a mean Preoperative grip strength of 40 % and Postoperative grip strength of 75 %. On statistical analysis using paired T test, the values were found to be significant with degree of freedom of 34 and p value of <0.0001

### Paired Samples Test

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>Lower</th>
<th>Upper</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Grip strength Pre Extension pre</td>
<td>-40.94</td>
<td>6.17</td>
<td>1.04</td>
<td>-43.06</td>
<td>-38.82</td>
<td>-39.235</td>
<td>34</td>
<td>.000</td>
</tr>
</tbody>
</table>

### Paired Samples Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Grip strength Pre</td>
<td>39.94</td>
<td>35</td>
<td>8.78</td>
</tr>
<tr>
<td>Grip strength Post</td>
<td>75.03</td>
<td>35</td>
<td>10.29</td>
<td>1.74</td>
</tr>
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</table>

### Paired Samples Correlations

<table>
<thead>
<tr>
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<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Grip strength Pre &amp; Grip strength Post</td>
<td>35</td>
<td>.012</td>
</tr>
</tbody>
</table>

### Paired Samples Test

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>Lower</th>
<th>Upper</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Grip strength Pre</td>
<td>-35.09</td>
<td>13.45</td>
<td>2.27</td>
<td>-39.70</td>
<td>-30.47</td>
<td>-15.438</td>
<td>34</td>
<td>.000</td>
</tr>
</tbody>
</table>
35 patients had a mean ulnar inclination of 14 degrees preoperatively and Postoperative ulnar inclination of 22 degrees. On statistical analysis using paired T test, the values were found to be significant with degree of freedom of 34 and p value of < 0.0001

<table>
<thead>
<tr>
<th>Pair</th>
<th>Ulnar inclination Pre</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ulnar inclination Post</td>
<td>35</td>
<td>4.86</td>
<td>.82</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pair</th>
<th>Ulnar inclination Pre &amp; Ulnar inclination Post</th>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>35</td>
<td>.076</td>
<td>.662</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pair</th>
<th>Ulnar inclination Pre</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ulnar inclination Post</td>
<td>-7.89</td>
<td>5.36</td>
<td>.91</td>
<td>-9.73 -6.04</td>
<td>34</td>
<td>.000</td>
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</tbody>
</table>

**DISCUSSION**

Fracture of the distal radius account for about one-sixth of all fractures treated in the emergency department. Although Abraham Colles claimed that external splintage can prevent deformity, it is undoubtedly proved that redisplacement is common with these fractures, paving way to malunion and its related complications. The functional outcome of fractures of the distal radius is controversial. Many surgeons believe that
conventional methods of treatment are inadequate for such fractures.

Malunited fractures of distal radius are very common in our day to day practice; which may be due to inadequate immobilisation, improper reduction or inability to maintain the reduction as a result of severe comminution often seen in these types of fractures. The common treatment option is corrective osteotomy – a major surgical undertaking, very often requiring a second surgery for implant removal. These patients present to us either with simple cosmetic deformity or with varying degrees of functional disability. This study proposes a novel method of physiological distraction of the malunion using a simple mini distractor; applying the principle of Callotasis.

Malunion following a dorsally displaced fracture of the distal metaphysis of the radius impairs the normal function of the radiocarpal and distal radioulnar joints. An increase in the dorsal inclination of the radiocarpal articular surface, combined with a loss of normal ulnar inclination in the frontal plane, causes a decrease in grip strength, a decrease in flexion and ulnar deviation of the hand and wrist, and a cosmetic deformity. More importantly, shortening of the radius relative to the distal end of the ulna, combined with a pronation deformity of the distal fragment, invariably results in incongruence and instability of the distal radioulnar joint. Such deformity adversely affects rotation of the forearm.
Although there is considerable information in the literature regarding the indications for, and the techniques and results of, corrective osteotomy for the treatment of malunited, dorsally displaced fractures of the distal end of the radius, there have been no studies on management of such malunited fractures without osteotomy of the distal end of the radius. In the current study, the results of physiological distraction for a dorsally angulated, post-traumatic deformity of the distal end of the radius in thirty-five patients were evaluated.

Despite appropriate initial treatment, malunion remains a common complication of distal radius fractures. Loss of normal palmar tilt, ulnar inclination and length of the distal radius or a combination of each may be the cause of this problem. The indications for the treatment of the patients in the current series included pain as well as limitation of the mobility of the wrist and forearm. These symptoms can be readily explained by the consistent pattern of deformity that occurs in association with a dorsally / volarly displaced fracture. The relationship between the accuracy of the anatomical repositioning after a fracture of the distal end of the radius and the quality of the functional result has been well documented. An alteration in the relationship of the carpus to its supporting articulation at the end of the radius adversely affects the transmission of load. This is manifested by a decrease in grip strength as well as in motion of the radiocarpal joint, which, in a patient who has a volarly displaced fracture, decreases extension of the wrist. Furthermore, the loss of ulnar inclination combined with the volar displacement of the distal radial fragment places the hand and wrist in a radial and palmarly directed position,
substantially reducing the mechanical advantage of the extrinsic flexor tendons as they pass through the carpal tunnel, which also contributes to a decrease in grip strength. The resultant improvement in grip strength after realignment of the deformity in these patients were due in large part to the salutary effect on the kinesiology of the wrist and its return to a more anatomical position at the end of the radius.

Displacement of the distal fragment also distorts the anatomical relationship of the distal radioulnar joint in the sagittal, frontal, and horizontal axes. Shortening of the radius in relation to the distal end of the ulna, as well as relocation of the distal end of the ulna so that it is dorsal to the radius, results in tightening of the triangular fibrocartilage complex, which limits rotation of the forearm. The loss of congruence between the sigmoid notch and the ulnar head similarly impedes the rotation of the forearm. Distortion of the articular cartilage within the distal radioulnar joint also leads to a painful arc of motion, which was prevalent in these patients.

Dorsal opening wedge osteotomy with iliac crest bone graft and plate fixation has been the traditional treatment; however, this technique may be complicated by postoperative swelling, loss of finger and wrist motion and extensor tendon rupture. The cost involved, the trauma to soft tissue, the resulting fibrosis and stiffness and a second surgery for implant removal only adds to the list of disadvantages.
The Pennig wrist fixator (Orthofix) that does not span the radiocarpal joint is also being utilized for correction of distal radius angular deformity after fracture. Distal pins were placed directly under the subchondral bone in the distal radius and the proximal pins placed traditionally in the distal third of the radius. An opening wedge osteotomy was performed and after correction was achieved with the fixator, the osteotomy was closed as per this method. This method also relies heavily upon osteotomy of the distal radius.

Ligamentotaxis is the usual method used for unstable fracture of distal radius. This was first described by Vidal. Principle of ligamentotaxis depends on the fact that the distal end of radius is surrounded by many important soft tissue structures like ligaments, retinaculum and tendons. In unstable fractures of distal radius if these structures are intact they remain attached to the fracture fragments. The structures act as an anchorage and stretching of these structures result in the fracture fragments falling into alignment and thus reduction is obtained. Bone, ligaments and tendons together form a visco-elastic unit which moves together. With axial distraction the fracture fragments are reduced and radial length is maintained. By changing the direction of distraction correction of dorsal displacement and radial tilt are achieved. Reduction and alignment are sustained by maintaining the distraction force with the help of external fixator till the fracture heals.

But in ligamentotaxis wrist movements are not possible as the frame extends from the radius to the metacarpals spanning
the wrist joint. Inability to move the wrist joint is one of the most notable disadvantages of ligamentotaxis. Early mobilization of the wrist is essential to prevent many of the complications of lower radius fractures especially in fractures with intra-articular extension.

In ligamentotaxis reduction is maintained due to stretching of the intact ligaments which are anchored to the fracture fragments. Continued stretching of the ligaments can lead to laxity of the ligaments and loss of reduction. If the ligaments are ruptured ligamentotaxis will not give the desired results. So also, ligamentotaxis in itself is an unstable fixation. Instability of the distal radio-ulnar joint which is a major factor in unstable fracture of distal radius is not taken care of in ligamentotaxis. Soft tissue healing around this joint is impaired and result in increased incidence of persisting pain around that joint.

In the current study, the mini distractor was positioned in an angle conforming to the relation of malunited distal fragment to proximal shaft to allow the distal radius to rotate slowly into the corrected position, restoring length, and palmar tilt, or inclination (Fig. 2). In other words, the plane of deformity was clinically and radiologically assessed and the distractor was placed in such a way that the line of distraction confirmed with the anatomical axis. All patients experienced improved function, pain relief, and improved grip and pinch strength. Many patients with successful results could literally feel the lunate pop back into the lunate fossa of the distal radius four or five weeks after lengthening had begun. This technique has
many advantages and great potential for improving results an alternative to distal radius osteotomy. Regional anaesthesia can be used and the technique can be performed as an outpatient procedure, without iliac crest bone grafting. Also, patients can gradually correct the deformity, negating acute pain and swelling associated with bone graft and plate fixation.

Fig.2a: Schanz pins and mini distractor
In this method of treatment, active finger movements are started from day one and all the movements of the wrist like dorsiflexion, palmar flexion, radial deviation and ulnar deviation are encouraged. Active movements of fingers, wrist and other joints of the limb reduce oedema and pain and increase circulation. It prevents post immobilization stiffness and osteoporosis. Patients are able to do light work with the mini distractor on. A housewife was happily doing all light household work three weeks after procedure, with the mini distractor on. An officer returned to work with the mini distractor on. One auto-rickshaw driver came to outpatient department for review four weeks after applying the mini distractor driving his auto-rickshaw with the mini distractor, although we never asked him to do so. A younger working in an automobile workshop returned to his work with the mini distractor after four weeks of fixing it, without our knowledge, but without any complications.
One of the most striking facts that this study throws light upon was the inadequacy of period of immobilisation as advocated by the current concepts. This study has shown that it is possible to distract those fractures considered to be clinically Malunited even at the end of 4 months. Hence it is mandatory to continue immobilization or maintain the fixation device for longer duration in unstable fractures of distal radius. The conventional practice of immobilization for 6-8 weeks and maintaining the ligamentotaxis frame for a maximum of 8 weeks is proved to be insufficient with this study. Hence these clinically united unstable fractures of distal radius should be considered only as “maluniting” and not “malunited” until 4 months are over after injury. In this study, we have not been able to distract any fracture beyond 4 months after the injury. Larger samples are required to identify this subset of highly unstable fractures requiring immobilisation for longer duration or early bone grafting to reduce the period of immobilisation.

**CONCLUSION**

In unstable fractures, distraction to correct deformity is effective even up to 4 months. Physiological distraction can be a cost effective and patient friendly alternative to the traditional treatment by dorsal opening wedge osteotomy with iliac crest bone graft and plate fixation especially since complications like postoperative swelling, loss of finger and wrist motion, extensor tendon rupture, soft tissue trauma leading to fibrosis and stiffness can be completely avoided. The cost involved is minimal; procedure is comparatively less time consuming and extremely patient compliant. A second surgery for implant removal only adds to the list of
disadvantages of a corrective osteotomy. However, physiological distraction does have its limitation. Physiological distraction can be performed only during the maluniting phase (nascent malunion). Once the injury is more than 4 months old, the callus is no more amenable to callotasis. Another limitation was in cases with extremes of dorsal / volar tilts which the currently available configuration of mini distractors fail to address. The efforts to device such a configuration is in the offing. Apart from the intended indication of this procedure, it was coincidentally observed that this procedure had produced some desirable effects in some of the patients like disappearance of reflex sympathetic dystrophy, stiffness and pain. But, conclusive evidence to this effect will require a larger study group which includes more patients with such pathology.

Overall, this is a novel technique to address the current problem of malunion in distal radius fractures, which has no references in any of the contemporary scientific literature.

This study is therefore being presented as a landmark study in the treatment of maluniting fractures of the distal radius in an adult.

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