INTRODUCTION

Very few subjects in contemporary orthopaedics has evoked as much thought and controversy as that of when and how to optimally reconstruct the Anterior Cruciate Ligament of the knee. Of the many techniques described for Anterior Cruciate Ligament reconstruction autografts of hamstring tendon or patellar tendon are practiced by most surgeons. Open and arthroscopic techniques of repair has been compared but has not shown significant difference in outcome in the long term follow up studies.

AIM OF STUDY

To evaluate and compare the two techniques of Anterior Cruciate Ligament reconstruction, the Lipscombe procedure using Semitendinosis and Gracilis tendon as grafts and the Modified Jones procedure using the bone patellar tendon bone graft.

The operative time, post operative knee scores, level of activity, harvest site pain, thigh atrophy, kneeling pain, and hamstring pain were assessed.

MATERIALS AND METHODS

This study was conducted at the Department of Orthopaedics, Medical College, Trivandrum, between 1996-2003. Study included 25 patients in the age group of 19-36 years, of which 23 were males.

All had complete rupture of Anterior Cruciate Ligament with or without associated other ligament and meniscal injuries. 9 patients had associated medial meniscal injury, 3 had associated Medial Collateral Ligament Injury and 2 had all the three injuries. All patients were initially treated conservatively with knee immobilization. Clinically Anterior Cruciate Ligament rupture was diagnosed by Lachman test, Anterior Drawer test, Slocum’s Anterior Drawer test, Jerk test of Hughston and Pivot Shift test of McIntosh. The average time of 7 weeks from initial trauma was given before Anterior Cruciate Ligament reconstruction was done. Anterior Cruciate Ligament was reconstructed only after making sure that it was an Anterior Cruciate Ligament dependent knee.
All patients underwent diagnostic arthroscopy to confirm Anterior Cruciate Ligament rupture and other associate injuries. Of the 9 patients with meniscal injuries, 7 patients underwent arthroscopic partial meniscectomy and 2 had arthroscopic meniscal repair.

The patients were divided randomly into 2 groups, and 15 patients underwent Anterior Cruciate Ligament reconstruction using Bone Patellar Tendon Bone Graft and 10 patients had Hamstring graft. In the Modified Jones procedure graft consisting of patellar tendon, 2-3 cm long and 10 mm wide distal attachment of patellar tendon from the Tibial tuberosity along with 2-3 cm long and 10mm wide segment from patella is harvested.

In Lipscombe procedure Semitendinosis and Gracilis tendons are harvested as grafts. In both the procedures the graft is passed through the tibial and femoral tunnels and secured with interference screw or staples. The time taken for both procedures was assessed. Post operatively the knee is immobilized in a ranger knee splint which allows upto 40 degrees of flexion and prevents extension of knee.

Post operatively the patient is put on static quadriceps exercise and is allowed upto 40 degrees of flexion. Non weight bearing mobilization is started on the first post operative day itself. Range of flexion is increased to 90 degrees by second week and full range of flexion by four weeks. Touch down weight bearing with knee brace is allowed by third week and full weight bearing allowed by eight weeks. Patient is not allowed to participate in contact sports for 9 months.

Patients were followed up at regular intervals monthly for the first six months and then at three monthly intervals. Patients were assessed using Knee Scoring Scale of Lysholm and Gillquist and International Knee Documentation Committee (IKDC) scoring system. In addition, activity level, harvest site pain, thigh atrophy, kneeling pain and Hamstring pain were assessed. All patients were followed up for a minimum period of 2 years.

**OBSERVATIONS AND RESULTS**

Lachman test was positive in all cases. 84% of patients had positive Pivot shift. Anterior drawer test was positive in only 52% patients. The Lachman test was the single most sensitive test in diagnosing Anterior Cruciate Ligament injuries.

Both the IKDC rating and Lysholm Knee score did not show any statistically significant difference between the two groups. 47% of the Patellar tendon group and 40% of the Hamstring tendon group showed normal grade as per the IKDC ratings and the same percentage of patients showed excellent ratings as per the Lysholm knee scores. The details of both these scores are given in Table I and Table II.

**Table I: IKDC Rating**

| Rating | Patellar | Hamstring Group |
|--------|----------|-----------------|
|        | No. | % | No. | % |
| A      | 4   | 40 | 5   | 33 |
| B      | 3   | 30 | 7   | 47 |
The post operative level of activity was assessed and it was found that 20% of both groups were able to return to strenuous activity level and 67% of Patellar tendon group and 50% of the Hamstring tendon group were able to return to moderate level of activity. The details of activity level assessment are given in Table III.
Table III: Activity Assessment Level

| Activity Level | Before injury | After injury |
|----------------|---------------|--------------|
|                | Patellar tendon | Hamstring group | Patellar tendon | Hamstring group |
| I (Strenous)   | 40%           | 40%           | 20%            | 20%            |
| II (Moderate)  | 40%           | 47%           | 50%            | 67%            |
| III (Light)    | 10%           | 13%           | 13%            | 6.5%           |
| IV (Sedentary) | 10%           | 0%            | 10%            | 6.5%           |

Harvest site pain or numbness was assessed and 55% of patients in the patellar tendon group and 20% of patients in the hamstring tendon group had donor site pain in the first 6 months. This pain was absent in both groups by the end of first year.

Thigh atrophy was seen more in the hamstring group than in the patellar tendon group. 73% of patients in the hamstring group had at least 10 mm of thigh wasting and details of this assessment is given in Table IV.

Table IV Thigh Atrophy

| Difference | Patellar tendon | Hamstring group |
|------------|----------------|-----------------|
|            | No. | %   | No.  | %   |
| 10 mm      | 5   | 50  | 11   | 73  |
| 10-20 mm   | 4   | 40  | 3    | 20  |
| 20 mm      | 1   | 10  | 1    | 7   |

Pain on kneeling was seen only in the patellar tendon group (35%) while hamstring pain was found only in the hamstring group (20%).

The average operative time for both procedures was 50 minutes with time varying from 40 minutes to 90 minutes. There was statistically significant difference in operating time between the two groups.

DISCUSSION
The results as shown did not show any difference between the two groups. This finding was similar to study conducted by Otero and Hutchison (JBJS 1994). Though they found that
hamstring graft was slightly inferior to patellar tendon graft in terms of laxity as per the Lachman Test and CT-100 Arthrometer testing, there was no significant difference in functional outcome scoring. Donor site pain was more in the patellar tendon group which too was similar to our finding.

Lachman test was found to be the single most important diagnostic test in diagnosing Anterior Cruciate Ligament injuries. This test had the advantage that this test could be performed even when there was severe pain.

**CONCLUSION**

Outcome for patients undergoing Anterior Cruciate Ligament reconstruction with hamstring tendon graft did not differ from that of patients with patellar tendon graft in terms of clinical stability, range of motion and general symptoms.

Even though there was no significant difference between the two groups, those in the patellar tendon group had increased anterior stability and were able to return to strenuous occupation. The difference in thigh atrophy between the two groups was not significant. The hamstring group had lower graft harvest site morbidity. Lachman test was the single most accurate test in diagnosing Anterior Cruciate Ligament injuries.

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Ganglion cysts occurring within sheaths of peripheral nerves are relatively rare entities. In the upper extremity, the most common site of involvement is the ulnar nerve as it passes through the cubital tunnel posterior to the elbow joint. Other common sites include the deep motor branch of the ulnar nerve at the wrist and the median nerve at the elbow. In the lower extremity, the peroneal nerve at the level of the knee and proximal tibiofibular joints is most commonly involved.

They usually present as a tender swelling that causes paresthesia and tingling in the distribution of the involved nerve. Very rarely it can present with neurological deficit. We present a case, who developed a progressive foot drop as a result of compression of the deep peroneal nerve by an intraneural ganglion cyst. He had neurological recovery after removal of ganglion.

**CASE REPORT**

56 yr old farmer presented with progressive weakness weakness of left leg 3 months duration. Initially it manifested as slipping off of footwear while walking. He had paraesthesia in the left lower limb. His symptoms progressed over 3 months and he had foot drop on presentation.

**CLINICAL EXAMINATION**

There was atrophy of the muscles of the anterior and lateral compartments of the right leg. 2 x 1 cms soft tissue swelling was noted on the lateral aspect just below and behind the head of fibula. The swelling was tender. Neurologic examination revealed decreased sensation to light touch in the distribution of the superficial and the deep peroneal nerves. Tinel’s sign over the peroneal nerve at the level of the fibular head was negative. There was footdrop with grade 0 power in dorsiflexors and evertors of ankle. Dorsalis pedis and posterior tibia) pulses at the ankle were equal to those of the contralateral side. The remainder of the physical examination was unremarkable.

Plain radiographs of the right ankle were obtained and were within normal limits without evidence of anterior impingement.

Ultrasonogram of the swelling was performed which revealed a well circumscribed swelling 1.5 x 1 cms in the common peroneal nerve. Electromyography and nerve conduction studies of the right lower extremity were considered but were not performed since the patient’s neurologic examination was thought to be diagnostic.

An excisional biopsy was performed subsequently performed. The histologic preparation
revealed a cystic structure filled with mucoid material and neural elements scarred with myxomatous degeneration. These histologic features were consistent with an intraneural ganglion cyst.

At the latest follow-up 8 months after the surgical procedure, the patient had a complete return of sensation to the lateral aspect of the leg and dorsum of the foot. Foot drop recovered after surgery.

**DISCUSSION**

Intraneural ganglion cysts are rare benign soft tissue masses occurring within the sheath of peripheral nerves. Analysis of the reported cases revealed a predominance of male patients, with a range of 9 to 74 years of age[5]. These cysts most commonly are accompanied by signs of nerve irritation such as numbness, tingling, and pain in the distribution of the affected nerve. A mass may also be palpated along the course of the nerve. Tinel's sign may also be present. The most reliable form of treatment involves complete surgical excision of the cyst, given that the recurrence rate for aspiration of an intraneural ganglion alone has been reported at about 30%[5]. The recurrence rate for surgical excision of an intraneural ganglion is not known.

The origin of intraneural ganglion cysts of the peroneal nerve is unclear. Some feel that the cysts arise from the proximal tibiofibular joint and enter the peroneal nerve proper by way of
the small recurrent articular branches. In a histologic study, Scherman et al. identified the cells lining common peroneal nerve cysts as myofibroblasts, cells of mesenchymal origin histologically similar to those found lining ganglion cysts of the wrist joint. These findings support the concept of intraneural ganglion cysts of the peroneal nerve originating from the proximal tibiofibular joint. Other authors have proposed that intraneural ganglions represent myxoid degeneration of connective tissue within the nerve occurring as a result of trauma. Regardless of the origin of these cysts, it is generally agreed that these masses are the result of a degenerative process and are not neoplastic in nature.

CONCLUSIONS

Intraneural ganglion cyst of the peroneal nerve who present with muscular weakness and a complete foot drop is extremely rare. Intraneural ganglion of the peroneal nerve should be considered in the differential diagnosis of foot drop associated with a soft tissue mass about the knee joint. Other differential diagnosis to be considered are cyst of lateral meniscus, Schwanoma and neurofibroma. Excision of the cyst is the suggested line of treatment.

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ACCELERATION OF FRACTURE HEALING IN HEAD INJURY – THE ROLE OF NEUROTRANSMITTERS

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In these modern times when high velocity trauma is rampant it is not uncommon to find victims with fractures who develop associated head injury also. But it is interesting to note that these victims who manage to survive their ordeal have faster healing of their fractures with exuberant callus formation.

AIM
In our study we try to assess the relation between head injury and fracture healing and also see whether neurotransmitters have a role in this phenomenon.

EFFECT OF HEAD INJURY IN A RAT MODEL

MATERIALS AND METHODS
We proceeded in two phases. In the first phase of our study we tried to verify whether fracture healing was indeed accelerated in head injury.

Our experimental work was done at the CENTER FOR NEUROSCIENCES, CUSAT.

We did our experiments on white Wistar strain male rats. They an inbred variety of rats and therefore the chance of genetic variations and hence confounding factors is less.

Two equal sets of rats were selected. One was kept as the experimental group and an equal number of rats were kept as the control group. Nonfatal head injury was induced in the experimental set of rats and fractures were induced in the left tibia of all the rats.

The progress of union of the fractures was assessed through weekly radiographic and cell studies from the fracture site of all the rats. All the X rays showed increased callus formation in the head injured group when compared to the control group.

Cells were taken from the fracture site of the rats weekly. After taking the cells they were transferred to PBS solution. The cells were centrifuged and were resuspended in RPMI [ROSEWELL PARK MEMORIAL INSTITUTE MEDIUM] medium enriched with 10% fetal calf serum. The cells are checked for viability by adding Tripham blue. The cells were incubated along with radioactive thymidine for 24 hours. Thymidine is an integral part of the DNA and its incorporation into the cell is considered to be a standard method of assessing cell proliferation. After 24 hours the excess radioactive thymidine is
washed off and the cells are resuspended in RPMI medium and they it is kept in a scintillation chamber to measure the radioactivity.

| Leg fracture | Leg fracture + head injury |
|--------------|----------------------------|
| 7190         | 11249                      |

The rats in the head injured group showed an increased incorporation of thymidine when compared to the control group.

Then we proceeded with the second phase of our study where we added various neurotransmitters to the cells along with radioactive thymidine and checked whether there was any difference in activity between the two groups.

We added 5 neurotransmitters to the cells namely
1. acetylcholine
2. norepinephrine
3. gamma amino butyric acid
4. serotonin
5. dopamine

Addition of nor epinephrine and Serotonin alone increased the incorporation of radioactive thymidine. All the other neurotransmitters were found to have an inhibitory effect. It was also found that acetyl choline has stimulatory activity on the receptors of these two neurotransmitters through its nicotinic receptors. Surprisingly the inhibitory neurotransmitter GABA was added along with a GABA – A receptor blocker it was found to have stimulatory activity through its GABA-B receptor.

| Neurotransmitters | 1 week | 2 week | 3 week |
|-------------------|--------|--------|--------|
|                   | Case   | Con    | Case   | Con    | Case   | Con    |
| NE                | 13639  | 8521   | 12314  | 7896   | 6049   | 5276   |
| NE + ACH + ATR    | 12267  | 7533   | 12070  | 7005   | 6434   | 5217   |
| SE                | 12700  | 8320   | 11760  | 8607   | 6868   | 4752   |
| SE + ACH + ATR    | 14681  | 8129   | 12679  | 7367   | 9131   | 5879   |
| GB + BI           | 12644  | 8451   | 10379  | 6447   | 7240   | 6828   |
| DA + BU           | 6793   | 8622   | 8477   | 8871   | 6160   | 6161   |

Radioactivity of the Cases

Radioactivity of Controls
All these point to the fact that in fractures associated with head injury there seems to be an increased response to facilitatory neurotransmitters either by an increase in the receptors or by an increase in the activity of the receptors that accelerates fracture healing.

**STUDY OF HUMAN SAMPLES**

We embarked on the second part of the study. We took samples from the fracture sites of patients who had developed both head injury and fractures. All the patients had fractures of the tibia and had severe head injury with Glasgow coma scale of less than 8.

| Leg fracture | Leg fracture + head injury |
|--------------|---------------------------|
| Patient1     | 20966                     |
|              | Patient1                  |
|              | 5675                      |
| Patient2     | 304191                    |
|              | Patient2                  |
|              | 6613                      |
| Patient3     | 20143                     |
|              | Patient3                  |
|              | 6489                      |

By adding radioactive thymidine and measuring its radioactivity which is an index of cell proliferation, which in turn is an indicator of the healing process.

All the samples from the experimental group showed increased radioactivity when compared to the control group. Then we added various neurotransmitters to the cells along with radioactive thymidine and checked whether there was any difference in activity between the two groups.

We added 5 neurotransmitters to the cells namely
1. acetylcholine
2. norepinephrine
3. gamma amino butyric acid
4. serotonin
5. dopamine

The following results were obtained:

| Neurotransmitters   | Patient 1 | Patient 2 | Patient 3 |
|---------------------|-----------|-----------|-----------|
|                     | Case | Con | Case | Con | Case | Con |
| NE                  | 41333          | 6434          | 297885          | 7896          | 20143          | 5276          |
| NE +ACH+ATR         | 43200          | 7533          | 215559          | 7005          | 130667          | 5217          |
| SE                  | 17291          | 8320          | 283777          | 8607          | 42945           | 4752          |
| SE+ACH+ATR          | 59262          | 8129          | 52797           | 7367          | 71096           | 5879          |
| GB+BI               | 93524          | 8451          | 341241          | 8871          | 97656           | 6828          |
| DA+BU               | 64148          | 8622          | 421358          | 8871          | 85479           | 6161          |
| GB+BI+NE            | 240200         | 9554          | 391435          | 8974          | 144848          | 7552          |
| GB+BI+SE            | 159262         | 8771          | 464644          | 9011          | 86824           | 7735          |
Addition of nor epinephrine and Serotonin alone increased the incorporation of radioactive thymidine. All the other neurotransmitters were found to have an inhibitory effect. It was also found that Acetylcholine has stimulatory activity on the receptors of these two neurotransmitters through its nicotinic receptors. Surprisingly the inhibitory neurotransmitter GABA was added along with a GABA – A receptor blocker it was found to have stimulatory activity through its GABA-B receptor. When we added the combination of GABA and Biculline to serotonin and nor epinephrine we found that the cell proliferation was increased many fold.

These confirm the findings of the experimental study, which showed increased cell activity on addition of particular neurotransmitters and that there is complex interaction between the various neurotransmitters.

All these point to the fact that in fractures associated with head injury there seems to be an increased response to facilitatory neurotransmitters either by an increase in the receptors or by an increase in the activity of the receptors that accelerates fracture healing.

CONCLUSION

The role of neurotransmitters in accelerating fracture healing, an area hitherto unexplored, has profound possibilities and our studies also point a finger in that direction. It is clear that facilitatory neurotransmitters like Serotonin, GABA and Nor epinephrine do have a role to play in accelerating fracture healing in head injury but further research is needed confirm this.
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SIGNIFICANCE OF BIOCHEMICAL PARAMETERS IN THE DIAGNOSIS OF HYPERPARATHYROIDISM
A RETROSPECTIVE STUDY OF 7 CASES OF HYPERPARATHYROIDISM

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INTRODUCTION
Like other metabolic bone diseases, hyperparathyroidism presents a challenge to all orthopaedic surgeons regarding diagnosis and management. Occasionally patients with normal calcium levels may show features of hyperparathyroidism. This study conducted at Medical College Hospital, Thiruvananthapuram. We review 7 cases of hyperparathyroidism which presented in our institution in the period of 1995 – 2000 and evaluate their biochemical parameters with an aim to find out the most specific test in diagnosing hyperparathyroidism.

AIM OF STUDY
1. To evaluate the significance of estimating various biochemical parameters in diagnosis of hyperparathyroidism.
2. To assess the most specific biochemical examination in diagnosing hyperparathyroidism.

MATERIALS AND METHODS
Study included 7 patients in the age group of 11 – 73 years of which 4 were males and 3 females. Five of these patients belonged to the 50 – 65 year age group. Five patients had primary hyperparathyroidism and 2 patients had secondary hyperparathyroidism, secondary to renal failure and rickets. Of these seven patients, four had pathological fracture and three had bony changes without pathological fracture. Irrespective of their biochemical parameters, all the patients had features of hyperparathyroidism.

The serum calcium, phosphorous, parathormone and calcitonin levels were assessed. The calcium and phosphorous levels were estimated using the absorption spectrophotometry technique of Fiskie. The parathormone level was assessed using the two site radio immuno assay technique (RIA). The Calcitonin level was assessed using the Enzyme Linked Immuno Sorbant Assay (ELISA) technique. The various levels of these biochemical parameters were correlated with the occurrence of hyperparathyroidism.
OBSERVATIONS AND RESULTS

Of the seven patients, three had normal calcium levels (43%) in spite of having clinical features of hyperparathyroidism. Two of the three who had normal calcium levels, had post absorptive hypercalcemia, that is hypercalcemia three hours after meal.

The phosphorous level was decreased in all but one case. The patient with normal level of phosphorous had associated renal failure. The parathormone level was increased in all seven cases. The calcitonin level was found to be increased in five cases and normal in two cases.

DISCUSSION

Incidence of hyperparathyroidism is 1 per 1000 per year in men over 60 and 2 per 1000 in females over 60 years. Peak incidence is seen between 30 and 50 years. Most common cause of hyperparathyroidism is single gland involvement (80%) of which adenoma is commonest.

As per literature Calcium level is increased in majority of cases of hyperparathyroidism (78%). But in our study 3 patients (43%) had normal calcium levels. Thus normal calcium level does not rule out hyperparathyroidism. Normal calcium level is 9-11 mg%.

The phosphorous level was decreased in all but one case of hyperparathyroidism. Normal Phosphorous levels can been seen when hyperparathyroidism is associated with either renal failure or rickets. Parathormone is a linear polypeptide with molecular weight of 9500 and has 84 amino acids. Normal plasma level is 10-55 pg/ml. it has a half life of 10 minutes and gets rapidly cleaved by the Kupffer cells in the liver into mid region fragment and carboxy terminal fragment which is biologically inactive. Since old RIA techniques measured parathormone using antibodies against mid fragment region they measured that fragment as well as intact hormone and gave false high values. To overcome this, two site RIA have been developed which uses one antibody against the amino terminal and one against the carboxy terminal. Parathormone estimation seems to be the most specific test in diagnosing hyperparathyroidism.

Calcitonin contains 32 amino acids and has a molecular weight of 3500 and is secreted from the parafollicular C cells. Calcitonin decreases serum calcium level by its direct action on osteoclast thereby preventing bone resorption. It also reduces the serum Phosphorous level. Calcitonin is secreted when calcium level reaches approximately 9.5 mg/dl. Calcitonin level was increased in five patients with hyperparathyroidism and normal in two. Normal Calcitonin level is < 265 pg/ml in males and < 120 pg/ml in females.

CONCLUSION

Hyperparathyroidism presents a challenge both in diagnosis and treatment. Normal calcium level does not rule out hyperparathyroidism. In those with clinical features of hyperparathyroidism but with normal calcium levels, post absorptive calcium levels must also be estimated. Phosphorous level may be normal in patients with hyperparathyroidism if associated with renal failure or rickets.
Parathormone estimation seems to be the most specific (100%) biochemical parameter in diagnosing hyperparathyroidism.
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COMPUTER ASSISTED PEDICLE SCREW FIXATION
CLINICAL EXPERIENCE WITH A NEWLY DEVELOPED SOFTWARE

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ABSTRACT

We have done the study at medical college Kottayam, in forty pedicles of ten patients with fractured vertebra at thoracolumbar region over a period of 2 years.

Procedure

Pre-operative CT scan section at the pedicle level is taken one vertebra above and one below the involved vertebra. The dicom image is converted into bitmap image and reference lines are drawn through the transverse processes and the spinous processes. The screw trajectory is attained in the image at the most suitable path of the pedicle. Intraoperatively reference pins are placed exactly at the same areas as of transverse processes and the spinous processes. The intraoperative image is live captured using a camera and is matched with the preoperative image and the awl is advanced into pedicle corresponding to the screw trajectory in CT image.

OBSERVATION

Out of forty pedicles instrumented in ten patients using computer assistance, the pedicle wall violation as demonstrated with 1mm thin CT scans was less than AMIOT Grade 2. Ideal placement was noticed in 80% and clinically insignificant perforation (Grade 2&3) in the rest.

CONCLUSION

Computer assisted pedicle screw fixation is a good technique for accurate placement of pedicle screws. Extra cost involved for surgery was negligible since a newly developed software was used.

BACKGROUND

Identifying the pedicle and placing the screw right through the pedicle has always been a demanding procedure even for the most experienced orthopaedic surgeon. Since King attempted his first Transfacetal screw fixation in 1944, there has been hundreds of contributions from different parts of the world in this field. The first pedicle screw fixation was attempted by Michel and Krueger in 1949. The technique was popularised by Roy Camille in 1986. Computer was introduced into the field in 1993, and since then the field witnessed a tremendous increase in the techniques for the accurate placement of screws.
The existing methods of screw placement include, the traditional techniques like the Intersection technique, Pars interarticularis technique, mammillary process technique, and techniques based on Funnel shaped pedicle approach zone, Roy Camille point and Weinstein point. Other tools that aid the surgeon in accurate placement of screws include fluoroscopic technique, stereotactic navigation which can be Image guided or Computer assisted, endoscopic technique, open lamina technique and ultrasound guided technique.

The popular technique used in this part of the world is fluoroscopy guided technique. This technique aids in identifying the entry point of the pedicle. However, further tracking of the guide is not possible and also the angle of trajectory is also not outlined by this technique. Further the operating personal is exposed to radiations and the apparatus is cumbersome. Moreover imaging the screw tip with regard to anterior cortex is difficult in the lumbar spine because of the anterior convexity of anterior margin of lumbar spine. Available literature shows a false positivity of 8.1% and a false negativity of 14.5% with fluoroscopy. The computer guided systems are highly accurate but prohibitively expensive.

It is in this background that new software was developed in this institution aimed at accurate placement of screws. The technique is cost effective and accurate as demonstrated in our study.

**AIM**
To Compare the rate of pedicle wall perforation by screw placement using ‘computer assisted technique’ using the new software and conventional fluoroscopic-technique.

**MATERIALS AND METHODS**

The study was conducted in the Department of Orthopaedics, Medical College Kottayam over a period of two years. The study was conducted in ten patients (forty pedicles), who presented with fracture at thoracolumbar vertebrae. Eight patients came to the emergency room while two were referred from elsewhere. Nine of these patients were operated within 48 hours after pre-op data processing while one case was operated after 5 days because of associated chest injury.

All patients with Grade-3 or lesser power, regardless of fracture stability were operated upon while others were excluded. Fractures that were above D-9 were excluded. All patients were less than 60 years of age.

**Data of ten Patients**

| No. | Sex/Age | level | Pedicles fixed | Neur. def. |
|-----|---------|-------|----------------|-----------|
| 1   | 33/M    | T9    | T8-T10         | Grade1    |
| 2   | 57/M    | T10   | T9-T11         | Grade0    |
|   |   |   |   |   |
|---|---|---|---|---|
| 3 | 55/M | T10 | T9-T11 | Grade 1 |
| 4 | 33/M | T11 | T10-T11 | Grade 0 |
| 5 | 45/M | T12 | T11-L1 | Grade 1 |
| 6 | 44/M | T12 | T11-L1 | Grade 0 |
| 7 | 45/M | L1  | T12-L2 | Grade 3 |
| 8 | 33/M | L1  | T12-L2 | Grade 1 |
| 9 | 51/M | L2  | L1-L3  | Grade 3 |
| 10| 48/M | L2  | L1-L3  | Grade 2 |

**PROCEDURE**

Thin slice (2mm) CT Scan was done preoperatively. The serial sections of the vertebrae immediately above and immediately below the fractured vertebra/vertebrae were analyzed and the section through the middle of the transverse process which included the pedicle was selected. The Dicom image thus obtained was converted to Bitmap without altering the magnification of the image. Then lines (according to standardized color coding) were drawn through reference points in the vertebrae. Two lines were drawn at a distance of 10mm from the tip of each transverse processes. Then a vertical line was drawn through the spinous process. The proposed screw trajectory was drawn through the pedicle path.

The image was processed using software and its transparency was increased to 50%. Intraoperatively, reference points were placed at a distance of 10mm from tips of transverse process of each vertebra using 2mm Schanz pins and a third reference point was placed on the spinous process. The intraoperative image was live captured using a camera and the live image is superimposed on the bitmap image. Then the reference points on the live image and the static image are matched so that they exactly lie over each other. The position is fixed and the awl is introduced into the pedicle exactly overlapping the screw trajectory drawn on the CT image. The depth of the screw is selected as measured in pre-op CT image.
Postoperatively thin slice CT scan was performed and the degree of cortical penetration was judged according to Amiot’s criteria.

**RESULTS**

The cases which were done with computer assistance were grouped as group-1 and fluoroscopically guided cases as group-2.

| Vertebra | Group1 (40 pedicles) | Group2 (40 pedicles) |
|----------|-----------------------|-----------------------|
| T-8      | 2                     | 2                     |
| T-9      | 4                     | 2                     |
| T-10     | 4                     | 6                     |
| T-11     | 8                     | 6                     |
| T-12     | 6                     | 8                     |
| L-1      | 8                     | 8                     |
| L-2      | 4                     | 4                     |
| L-3      | 4                     | 4                     |

Pedicle screw perforation was evaluated using thin slice CT images and in Consultation with radiologist (single blinding).

Pedicle wall perforations were graded according to the classification by Amiot.

**Classification (Louis Philippe Amiot)**
RESULTS

| Placement | Group1 | Group2 |
|-----------|--------|--------|
| GRADE 1  | 32     | 22     |
| GRADE 2  | 8      | 10     |
| GRADE 3  | 0      | 4      |
| GRADE 4  | 0      | 4      |
| GRADE 5  | 0      | 0      |
| TOTAL    | 40     | 40     |

STATISTICAL ANALYSIS

Applying Chi-square test, the value obtained is 8.888 which is higher than the value obtained with 2 degrees of freedom under a probability of .05 . Hence accuracy is significant at 2% level.

Students \( t \)-test- comparison of means

\[ p = 0.05 \quad \text{t value} = 3.6 \]

\( t \) (\( p = .05 \)) \( > 2.8 \) Statistically significant

Pedicle screw placements were much more accurate with computer assistance Grade1 (Amiot grading) pedicle screw placements were 80% with computer assisted technique as against 50% with conventional methods.

CONCLUSION

Computer assisted pedicle screw fixation is superior to conventional methods with regards to thoracolumbar spine where higher degrees of accuracy is needed. Extra cost involved for surgery was negligible since a newly developed software was used.

REVIEW OF LITERATURE

[1] Louis Philippe et al SPINE 200: 25; 600-614
[2] Andrew S Youkilis NEUROSURGERY; 48 April 2000: 771-777
[3] William S Choi Neurosurgery Oct 2001: 872-878 Perforation 87.3 %
INTRODUCTION

The anatomy of the acetabulum is complex and exposure for fracture reduction is difficult. Displaced fractures of the acetabulum are best treated with anatomical reduction and rigid internal fixation. Residual displacement of more than two millimeters may lead to progressive post-traumatic osteoarthrosis and a poor functional result.

The subject of acetabular fractures is one that will interest most trauma surgeons. They pose a challenge both in their diagnosis and their management. Operative treatment of displaced acetabular fractures should now be the standard of care. The purpose of this study was to evaluate the early results of open reduction and internal fixation displaced fractures of the acetabulum.

This paper reports a series of acetabular fracture fixation performed at Amrita Institute of Medical Sciences, Kochi, Kerala.

KEY WORDS

acetabulum, fracture acetabulum, fracture-dislocation.

MATERIALS AND METHODS

From March 2001 to May 2004 twenty-eight patients underwent open reduction and internal fixation for displaced fracture acetabulum. Patients were either directly admitted through the emergency department or referred from another institution specifically for treatment of the fracture acetabulum after stabilization of their general medical condition. Twenty-six patients were included in this series; two of the patients lost for follow up. Twenty were male patients and six females; age was 18 to 65 yrs (mean 36 yrs). In twenty-five patients mechanism of injury was road traffic accident and one patient had fall from height. Twelve patients had associated other injuries. Eight patients (30.7%) had posterior dislocation of hip. Six patients
had sciatic nerve injury (23.07%). Three patients had posterior cruciate injury (11.5%).
Three standard radiographs (pelvis with both hips, Judet oblique views) and CT scan with 3 D
reconstruction was performed for all patients. Fractures were classified according to
Letournel’s classification system.

![Figure 1: Pie diagram showing number of simple fractures](image1.png)

![Figure 2: Pie diagram showing number of associated types](image2.png)

**OPERATIVE TECHNIQUES**

Close reduction was done in emergency for patients with dislocation and stability was
checked after the reduction. Preoperatively all patients were given skeletal traction.
Indications for surgery were based on displacement, stability, roof arch angle (Figure 3) and
polytrauma.

(On AP view medial roof arch is measured by drawing a vertical line through roof of
acetabulum to geometric center of head and second line through point where fracture
intersects roof of the acetabulum and to geometric center)
Patients were positioned supine or in the lateral position according to the approach used. Kocher Lagenbach and triradiate approach was used for posterior wall or column fractures and ilioinguinal approach for anterior column. In some of the patients with associated type fractures, after posterior reduction and fixation there was acceptable anterior reduction; so were left alone.

|                      |     |
|----------------------|-----|
| Kocher Lagenbach (K-L) | 14  |
| Ilioinguinal (II)     | 4   |
| Triradiate            | 4   |
| K-L and II            | 2   |
| Triradiate and II     | 2   |

Different modes of fixation were used to hold the reduction, in all of the patients long reconstruction plates in buttress mode were used in addition to long lag screws. In two patients $1/3\text{rd}$ tubular plate was used as a spring plate (Figure 4) and two of the patients reduction was held temporarily with Weber wire technique (Figure 4).
Figure 4 Spring plate used for fixation of quadrilateral plate in bicolumn fracture
Postoperative all patients were given CPM except who had PCL injury. DVT prophylaxis (low molecular weight heparin) and prophylaxis for heterotropic calcification (indomethacin for 3 weeks) was given for ten patients.

Patients were ambulated non-weight bearing for 6 weeks then partial weight bearing for another 6 weeks then full-weight bearing. Follow-up data was collected and patients were assessed on their scheduled revisits. Functional outcome was assessed with a Harris hip scoring system, which is followed regularly for hip disorders in this hospital. (Apex. 1).

Radiological outcome of fixation was determined through post-operative plain radiographs of the three standard views. Follow up protocol was 6 weeks, 3 months, 6 months, 1 yr and 2 yr. Patients followed in this study was from three months to 40 months (mean 14.6 months).

**RESULTS**

Radiological grading-
Anatomical reduction was achieved in three patients (11.5%) Figure 4, residual displacement of less than 2 mm was there in fourteen patients (53.8%) Figure 7 and more than 2 mm in nine patients (34.6%) Figure 8.
Fig. 7 showing anatomical reduction in posterior wall fracture

Fig. 8 Transverse + posterior wall showing residual step

Functional results -
In five patients (19.2%) score was excellent, in twelve patients (46.1%) good, in five patients (19.2%) fair and for four patients (11.5%) score was poor (Figure 4)

Figure 9 Graph showing relation between function and postoperative reduction
DISCUSSION

Open reduction and fixation of displaced fracture acetabulum leads to better functional outcome. In our series good to excellent outcome was achieved in 65.2%, which were close to the results reported in large series. Matta reported 40% excellent and 36% good results in 262 displaced fractures. Mayo also reported 75% good to excellent outcome in 163 operatively treated fractures. Good to excellent outcome was related to reduction demonstrated radiographically. Other factors affected functional outcome are patients age, damage to femoral head, sciatic nerve injury and infection. We did not experience heterotopic ossification even in those patients who were not given indomethacin as
prophylaxis. Two patients had deep surgical wound infection that had poor outcome. One patient had deep vein thrombosis that was not given DVT prophylaxis. One patient had femoral nerve palsy, which is rare complication. This patient had posterior wall and transverse fracture, which was fixed with Kocher-Lagenbach approach. Reexploration was done by ilioinguinal approach but nerve was found to be intact. Quadriceps strength was recovered within 7 months. In our series we did not have iatrogenic sciatic nerve palsy, which is documented about 2 to 6% in literature. Intraoperative sciatic nerve monitoring was not used in this series.

The drawbacks of this study were number of patients in this series where insufficient and follow up period was too short as the functional outcome may change on long term, especially patients who had dislocation of head which are prone to avascular necrosis and secondary osteoarthritis. (Figure 6)

CONCLUSION

Accuracy of reduction of acetabulum fractures predicts functional outcome, which depends on complexity of fracture and expertise of the surgeons. Poor outcome is associated with inadequate reduction, femoral head damage, and infection.
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[10] Intraoperative evoked potential monitoring in acetabular surgery. Calder HB. *Clin Orthop.* 1994 Aug (305):160-7.
INTRODUCTION

The anatomy of the acetabulum is complex and exposure for fracture reduction is difficult. Displaced fractures of the acetabulum are best treated with anatomical reduction and rigid internal fixation. Residual displacement of more than two millimeters may lead to progressive post-traumatic osteoarthrosis and a poor functional result.\(^1\)

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Table 1 showing approaches used for different patients

| Approach                        | Patients |
|---------------------------------|----------|
| Kocher Lagenbach (K-L)          | 14       |
| Ilioinguinal (II)               | 4        |
| Triradiate                      | 4        |
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Figure 5 Weber technique used to hold the reduction

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INTRODUCTION

Ewings Sarcoma is the sixth commonest malignant bone tumour and of these only less than 2% occurs in the clavicle. Clavicle being an uncommon site this case is reported.

Case Report

8 year old male child presented with pain and swelling over the lateral aspect of clavicle of 2 months duration [Fig. 1]. Examination revealed a soft to firm swelling which was warm and tender. The swelling had all features of aggressive neoplasm. No regional lymphadenopathy was present.

Figure 1

Radiological picture showed osteolysis lateral end of left clavicle and periosteal reaction with a soft tissue mass. Fine needle aspiration cytology (FNAC) of the swelling showed a round cell neoplasm. CT scan of the chest and Technetium 99 bone scan was done to rule out metastasis.

The child was treated as per the treatment protocol followed at Medical College, Thiruvananthapuram for Ewings Sarcoma which includes biopsy confirmation, neoadjuvant chemotherapy followed by definite surgical procedure. The neoadjuvant chemotherapy
The VAIA regimen \[(Vincristine (1.5 mg/m^2), Adriamycin (50 mg/m^2), Ifo- 

samide (750 mg/m^2), Dactinomycin (100 mg/m^2)\ given as 2 cycles at 4 weeks interval. The definitive surgical procedure was done 3 weeks after second cycle. Operative procedure was through a subcutaneous incision to expose the clavicle and extra periosteal excision of the tumour was done [Fig. 2]. Absolute haemostasis was attained. Post operatively the arm was immobilised in an arm to chest strapping for 3 weeks. Post op X-ray showed complete excision of the tumour [Fig. 3].

**DISCUSSION**

James Ewings (1886-1943) was the first to describe this tumour. It is the sixth commonest primary malignant bone neoplasm and constitutes 10% of all malignant bone neoplasms. Ewings Sarcoma has 1.4% incidence in clavicle and is a rapidly disseminating malignancy with 20% metastasis. Chemotherapy in Ewings Sarcoma can be neoadjuvant chemotherapy, concomitant chemotherapy or adjuvant chemotherapy.
Neoadjuvant chemotherapy also known as Anterior Chemotherapy refers to chemotherapy given before definitive treatment. Advantages of neoadjuvant chemotherapy include decreases in tumour bulk, increase in the potential for local control, decrease in micrometastasis and decrease in the number of cells shed at time of surgery thereby decreasing the recurrence.

Concomitant chemotherapy or concurrent chemotherapy refers to chemotherapy given during radiotherapy. This increases the response to radiation. It is not commonly used now in Ewings sarcoma.

Adjuvant chemotherapy or Posterior chemotherapy is given after definitive surgery or radiotherapy. This kills micro metastasis and is of immense value in Ewings sarcoma and is now considered mandatory.

Combination Chemotherapy improves long term disease free survival rate above 50%. Various regimens used in Ewings are:
- **VAC Regimen**
  - Vincristine
  - Adriamycin
  - Cyclophosphamide
- **VACA Regimen**
  - Actinomycin
  - Superior than VAC (IESS 1 Study)
- **VAIA Regimen**
  - Vincristine
  - Adriamycin
  - Ifosfamide
  - Dactinomycin

Radiotherapy used to be the gold standard prior to chemotherapy. Local recurrence following even the most adept and skillfully delivered radiotherapy is 30%. Secondary sarcoma and
growth disturbance are other complications of radiotherapy.

Supportive care for Ewings Sarcoma patients on treatment is critical because irradiated volumes are large and chemotherapy is intensive. Blood transfusion, routine skin care, antibiotic cover, G-CSF, avoidance of vigorous physical activity are some of them. Long term follow up is mandatory for all patients with Ewings Sarcoma due to chance of recurrence.

Results of Bone Marrow transplantation, though in the experimental stage, with autologous or allogenic bone marrow are encouraging. 5 year survival rate is 50-65%.

Prognosis is poor for tumors with metastatic when compared to those with no metastasis. Pulmonary metastasis has got better prognosis than those with multiple bone lesions intensive chemotherapy is required for such patients. Survival rate is poor for patients developing metastasis during or after chemotherapy.

CONCLUSION

Clavicle is an uncommon site for Ewings Sarcoma. It is a systemic disease responsive to chemotherapy. Prior to chemotherapy, 90% patients died of systemic metastasis in 2-5 years. Chemotherapy has to be individualized for each patient and best results are obtained with neoadjuvant chemotherapy. First chance to cure Ewings with chemotherapy is the best chance as recurrent or residual disease is chemo resistant.

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CHONDROBLASTOMA OF ACROMION PROCESS OF SCAPULA
A CASE REPORT

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ABSTRACT
We report an unusual case of chondroblastoma occurring in the acromion process of scapula in a 32 year old adult male patient. According to literature, chondroblastoma is a tumour of epiphyses of long bones, usually confined to an age group of 12-24 years ie adolescents and young adults.

In our case, a 32 year old male presented in our institution with complaints of left shoulder pain of 1 year duration. X-ray of the affected region showed a well demarcated, radiolucent lesion at the tip of acromion process, with cortical expansion. A C.T. scan done subsequently demonstrated a cortical break. The initial needle biopsy report came as osteoblastoma following which we did an excision biopsy. The histopathological examination of the excised tumour showed characteristic features of chondroblastoma. Functional results after the excision were excellent. Imaging studies to rule out distant metastases turned out negative and now the patient is under follow-up observation.

According to most textbooks on bone tumours, the incidence of chondroblastoma in the whole of scapula is < 2% and only 2 cases of chondroblastoma arising from acromion has been reported in literature so far. The case is presented because of the rarity in the site of occurrence and because of its rare presentation after skeletal maturity.

INTRODUCTION
Chondroblastoma, a rare primary bone tumour, was originally described by Kolodny in 1928, as a cartilage containing giant cell tumour. In 1928 Ewing, called it as “Calcifying giant cell tumour”. Codman in 1931, characterised it as “Epiphyseal chondromatous giant cell tumour” and described its distinct clinical, pathological, and radiological features. His research led to the eponymous name “CODMAN’S TUMOUR” and resulted in identifying chondroblastoma as a distinct entity.
In 1942 Jaffe and lichenstien, introduced the term Benign chondroblastoma of bone. They rejected the concept that the tumour was of giant cell origin and proposed that it arose from immature cartilage cells. Sixty years since chondroblastoma has been identified as a distinct entity, there have been very few reports of its occurrence in scapula and only 2 cases have been cited to arise from the acromion process.

We present a rare case of chondroblastoma arising from the acromion process of scapula in an adult male, in his 4th decade of life. The patient was informed that his case would be presented.

**CASE REPORT**

A 32 year old male patient consulted our outpatient department in March 2004 for a left shoulder pain which has been present for one year. The pain was dull aching in type, aggravated by lifting weights and also towards evenings. There was occasional radiation to the arm. The pain was initially under control with analgesics, but in the last one month it had become more severe. There was no history suggestive of distal neurovascular deficit.

On examination, there was a slight prominence of acromion process of his left shoulder. The movements of this shoulder were full range, with some pain during movements. There was no wasting of muscles and no dilated veins visible over the affected joint. On palpation, the affected acromion was tender without any alteration in consistency. In the distal parts of the affected arm, pulses were felt normally and no neurological deficit was seen.

A complete blood count and sedimentation rates done were within normal limits. The roentgenogram of the affected part showed an expansile, osteolytic lesion at the tip of acromion process of left scapula, measuring about 3x2 cm. There was no evidence of any periosteal reaction. Specks of calcification were sparsely visible in the lesion.

We subsequently got a C.T. scan done, which confirmed the expansile, osteolytic nature of the lesion, arising from the tip of acromion, and showed a break in the cortex.
Radiological differential diagnoses we were considering at this stage included giant cell tumor, eosinophilic granuloma, chondroblastoma, osteoblastoma, chondrosarcoma etc.

Fine needle aspiration cytology report initially suspected osteoblastoma. We did a wide excision of the lesion under general anesthesia, and sent the specimen for histopathological analysis. Intraoperatively the tumour was found limited to tip of acromion and it was possible to obtain adequate margins. The material obtained was firm in consistency, reddish brown in colour with white glistening foci of cartilaginous appearance. Microscopy of the specimen showed the neoplasm to be composed of sheets of polygonal or round cells having uniform round or oval nuclei with hyperchromasia, with an eosinophilic cytoplasm. There was no evidence of atypical mitoses. The cells were separated by chondroid and myxoid stroma. There was a lattice like pericellular rim calcification, imparting a “chicken wire” appearance. There were scanty number of giant cells and there was a few areas showing extensive calcium deposition. No surrounding soft tissue permeation was present and the surgical margins were found free. Thus a definitive diagnosis of chondroblastoma was made.

As the wide excision done was considered adequate enough treatment for chondroblastoma, no revision procedure was required. We did a C.T.scan of chest to rule out a rare event of lung metastasis. Six months after surgery, patient is having excellent functional results. He has resumed most of the ordinary activities of the limb and is pain free. His asymptomatic state continues and he remains on follow-up.
DISCUSSION

Chondroblastoma is a rare benign primary tumour of bone derived from immature cartilage cells, with a preferential localization in epiphyses of long bones. It constitutes only one percent of all bone tumours. Majority present in the second decade of life, and in most patients, epiphysis is open at the time of presentation. Presentations after skeletal maturity are rare, but cases have been reported upto 73 years. 98% of the lesions are, either epiphyseal or epiphyseal-extending to metaphyseal region. There is a 2:1 male preponderance in incidence. Chromosomal studies suggest a preferential involvement of chromosomes 5 and 8 in chondroblastoma.

Mayo-smith et al in their review of 5 large series has shown that the commonest site of occurrence for chondroblastoma is lower extremity-72%; mainly about the knee, in distal femur and proximal tibia[18% each]. Other common sites include humerus[17%], proximal femur[16%], foot[12%]- mainly in tarsal bones;os-calcis and talus,and small bones of hand[10%]. Rare sites include innominate bone, ribs, skull bones, mandible, maxilla, vertebra, patella, sternum and scapula. Primary presentation in scapula has an incidence of < 1% and is reported mainly in the body. Only 2 cases have been reported in literature, citing occurrence in the acromion process of scapula.

Patients most often present with mild pain, which has been present for an average period of 20 months and frequently referred to an adjacent joint. Radiographically the lesions are eccentrically located in the epiphysis and are primarily osteolytic. There may be a thin rim of sclerosis and specks of calcification.

Histologically the tumour is composed of uniform polyhedral closely packed cells, ultrastructural features of which suggest immature chondroblast derivation. The single nuclei of these cells may show indentation, moderate lobulation, hyperchromasia and increased mitoses representing biologic activity, but atypical mitoses are not seen. Mature cartilage cells and lacunae are usually not seen and cells are surrounded by what is called chondroid matrix. It is typically a pinkish amorphous substance deposited as less than 1mm nodules in the stroma. The calcium deposited in the chondroid matrix mimicks the calcifications occurring in the zone of calcification of a normal growth plate. This fine lattice like pericellular calcification is called “chicken wire” appearance as revealed by reticulin staining.

Microscopic picture showing immature cartilage cells in chondroid stroma with pericellular calcification imparting a “chicken wire” appearance

S-100 immunostaining is also used to differentiate the cartilage derivation of the tumour and differentiate it from GCT, aneurismal bone cyst etc. Minute 1-2 mm clumps of calcification may also be seen in these tumours. Multinucleate giant cells are commonly found as an
integral part of the tumour. They are probably reactive elements. They are evenly distributed among the cluster of chondroblasts. Regions containing large number of giant cells may mimic GCT. Conservative resections are usually effective in chondroblastoma. Usual practice is curettage with bone grafting. Overall recurrence ratio is 16% and may be treated by repeat curettage. Radiation therapy is almost always unnecessary and may be associated with malignant transformation.

CONCLUSIONS

Chondroblastomas are benign lesions, rarely locally aggressive, usually confined to epiphyses of long bones. Rarely it can present at atypical sites like acromion process of scapula. Early diagnosis and appropriate treatment can prevent recurrences and a rare metastatic event and its consequences.

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KEINBOCK’S DISEASE

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INTRODUCTION

Avascular necrosis of Lunate or lunatomalacia was originally described by Robert Keinbock in 1910. Keinbock was born in Vienna, qualified in Medicine in 1895, had his post graduation in Paris and London. He published the article in 1910.

Exact etiology of this disease is unknown and treatment of choice remain a matter of heated debate. Its various other names such as osteochondritis of lunate, aseptic necrosis of lunate, traumatic osteoporosis etc. reflect this and a large number of surgical procedures for the condition indicates ongoing controversy in treatment selection.

ETIOLOGY OF KEINBOCKS DISEASE

The first description of collapse of carpal lunate was given by Peste, in 1843 even before the advent of radiography. He believed the lesion to be a fracture with a traumatic etiology. In 1910, Keinbock also ascribed this lesion to repeated sprains, contusion and subluxation with ligamentous and vascular injury resulting in loss of vascularity of lunate. In 1928, Hulten(2) suggested that a relative discrepancy between distal radius and ulna predisposes certain individuals to avascular necrosis of the lunate bone. In a study of 400 individuals of Swedish descent, with normal wrists and 23 patients with Keinbock’s disease, he found that there was an increased incidence of avascular necrosis in those patients in whom the radius extended at least 2 millimeters more distally than ulna. 78 percent of his patients with the disease had a short ulna where as only 23% of controls had a short
ulna reflecting the possibility of an abnormal wrist kinematics caused by the discrepancy in radial and ulnar length. He stated that this incongruity in the articular surface contributed increased shear forces on the lunate bone thus, the development of avascular necrosis. Hulten called this “Negative ulnar variance”.

Person in 1945 suggested that Keinbock disease initiated with a compression fracture of lunate. This makes certain areas of the bone, necrotic and ulnar minus variants are more susceptible to sustain stress fractures of lunate due to the unfavorable mechanical relationship.

Acute fracture as an etiology has been implicated in many series. Beckenbaugh and associates found fracture lines in 82% of their patients and many authors have documented this after the advent of Computed Tomography.

**Role of Vascularity of Lunate**

Gelberman and associates described a method of establishing the degree of ulnar variance. This is done by extending the line from the distal radial articular surfaces towards the ulna and measuring the distance between this line and the carpal surface of ulna.

Palmar and colleagues found that the ulnar variance changes with varying degrees of forearm rotation and this change was least with the elbow flexed 90 degrees.

Gelberman and associates described a method of establishing the degree of ulnar variance. This is done by extending the line from the distal radial articular surfaces towards the ulna and measuring the distance between this line and the carpal surface of ulna.

Lee and Gelberman found that the intraosseous blood supply consisted of three patterns. A single vessel, either dorsal or volar supplying the entire bone. Several vessels in both dorsal and volar surface of lunate with or without central anastomosis. About 20% persons have a single palmar lunate vessel. These people are more prone to develop Keinbocks’ disease.
Intraosseous blood supply follow one of the three patterns. Central anastomoses follow a ‘Y’ patterns in 59%, ‘I’ in 30% and ‘X’ in 10%.

**Role of Wrist Kinematics**

Theories on carpal bone mobility and intraosseous pressures fall into 2 areas. Classical anatomists divided the carpus into two rows. The distal row consists of hamate, capitate, trapezium and trapezoid with the distal pole of scaphoid and the proximal row consisted of triquetrum, lunate and proximal scaphoid pole. The theory stated that flexion and extension occurred at the mid carpal joint and radial and ulnar deviations by the scaphoid sliding down the slope of the distal radius.

Talesnik\(^{24}\) in 1976, modified the column theory originally proposed by Navarro in 1921 and suggested that central column consisting of lunate, capitate and hamate controlled flexion and extension of wrist and radial and ulnar deviation occurring by rotation of scaphoid and triquetrum about the control column. Lichtman\(^{22}\) suggested the “Oval Ring Concept” which explains that movement occurs between capitate and lunate in radial and ulnar deviation as well as flexion an extension. He implies that scapho trapezial and triquetro-hamate joints act as physiological units which if damaged, cause abnormal movements between bones.

Ruby et al\(^{23}\) in 1988 found that the scaphoid rotated a mean of 51° in radial and ulnar deviation compared with lunate rotation, of 35°.

Female subjects were more likely to have a column type wrist. This variation may affect the result of treatment of scapho-lunate dissociation by scapho lunate fusion. A “CR” index is proposed so that the tendency of a wrist towards row or column theory can be quantified. This may be used to predict the success of some surgical procedures in the treatment of scapho lunate dissociation. Single or repeated trauma in patients with lunate at risk leads to Keinbocks disease.

**Diagnosis of Keinbock’s Disease**

Keinbock’s disease should be considered in any patient presenting with wrist pain of uncertain origin as in its early stages the disease may be clinically indistinguishable from other causes of wrist pain. Wrist pain and stiffness is of insidious onset usually following trauma. Roentgenograms during this stage are of little help, as they may be negative. It commonly occurs in the age group 20 to 40 years. The Male to Female ratio is 2 : 1. On examination there will have tenderness dorsally about the lunate. Synovial swelling consistent with localized synovitis may be present. Grip strength is significantly decreased compared to that of normal hand, and the range of motion of the wrist progressively decreases. The diagnosis is established by...
radiographs, particularly in the later stages of the disease where the sclerotic appearance of lunate is so characteristic. Early in the course of Keinbock’s disease the radiographs may be normal. Keinbock’s disease has been found in association with sickle cell disease, carpal coalition, gout and cerebral palsy.

**Radiological Appearance and Classification**

Keinbock’s disease is diagnosed from characteristic x ray changes. In early stages X ray may be normal. Increased density, often associated with fracture line occur later followed by fragmentation and progressive collapse of lunate. This causes proximal migration of the capitate, widening of proximal carpal row and, frequently, rotation of the scaphoid, causing it to appear foreshortened in anteroposterior radiographs. This fore shortening has been referred to as RING Sign.

Tomogram may be helpful in identifying the linear fractures or localized areas of sclerosis not readily apparent in plain radiographs.

**Lichtman Classification**

This is the most widely used staging system to select the reasonable treatment option. This system of staging was originally proposed by Stahl and modified by Lichtman and colleagues and consists of four stages

**Stage I**

Acute stage presents as wrist sprain. Roentgenograms are normal except for the possibility of either a linear or a compression fracture. Unless this is visible, this stage is clinically indistinguishable from a wrist sprain. Scintigraphic imaging may be helpful at this stage.

**Stage II**

Patient present with recurrent pain, swelling and tenderness in the wrist. There are definite density changes apparent in the lunate relative to other carpal bones; however, the size, shape and anatomic relationship of the bones are not altered. Significant fracture lines may be noted. Later in this stage antero posterior roentgenogram shows loss of height on the radial side of the lunate.

![Figure 4](image)

**Stage III**

Patients present with pain and limitation of movements of the involved wrist. Radiologically the carpal lunate has collapsed in the frontal plane and is elongated in the sagittal plane. The capitate migrates proximally. Scaphlunate dissociation, rotation of scaphoid (ring sign) and ulnar deviation of the triquetrum may be seen on the anteroposterior x rays.

The degree of collapse can be evaluated by carpal height ratio. Carpal height is the distance between the base of 3rd metacarpal and the distal radial articular surface as determined on a posteroanterior
The carpal height ratio is defined as the carpal height divided by the length of the third metacarpal. In normal individuals, this ratio is $0.54 \pm 0.03$. Carpal height ratio is considered as an important index as the factors determining the results of treatment in Stage III appear tied to the degree of collapse of lunate.

**Stage IV**
Clinical features of stage III disease along with degenerative changes in roentgenogram.

**Stage III**
Patients present with pain and limitation of movements of the involved wrist. Radiologically the carpal lunate has collapsed in the frontal plane and is elongated in the sagittal plane. The capitate migrates proximally. Scapholunate dissociation, rotation of scaphoid (ring sign)
Figure 6  Modified Lichtman

Later stage 111 was classified as a and b. In stage b there is scapholunate dissociation.

**Radiological Assessment of Keinbock’s Disease**

In all cases suspected to have Keinbock’s disease posteroanterior roentgenogram should be obtained with wrist in neutral position with elbow flexed 90 degrees and shoulder abducted 90 degree.

- Ulnar variance
- Lichttman’s stage
- Radial inclination
- Lunate fossa inclination
- Carpal height ratio
- Carpal ulnar distance
- Stahl index
- Lunate covering ratio

**Ulnar variance**

Commonly used methods are:

a. Project a line Technique
b. Concentric circle technique of Palmar
c. Method of perpendiculars

All these methods are highly reliable. The method of perpendicular is the most reliable.

**X-ray**

**Lunate Morphology in Keinbock’s Disease**

The lunate has been described by Kauer as being thinner dorsally than volarily when measured proximal to distal. A study to measure the shape of the lunate in order to compare dorsal and volar thickness after recognizing clinically a group of patients with scapholunate dissociation and a volar flexed lunate. According to lateral lunate morphology in x-ray, lunates could be classified into 2 types. Type D lunate have a thinner dorsal segment Type V lunates with a thinner volar segment, Type N have equal dorsal and volar segments. Lunate Wedge Ratio is calculated by dividing the volar segment with the dorsal segment thickness.

- Type D have wedge ratio > 1 and correspond to Kauer’s description.
- Type V lunates have WR < 1
- Type N lunates, WR = 1

Interestingly in this study scapholunate dissociation and volar intercalated segment instability (VISI) demonstrated type V lunate in almost two third of the patients.

**Other associated conditions**

- Sickle cell disease
- Cerebral palsy
- Gout
- Carpal coalition

A case of multiple hereditary osteochondromata and unilateral Keinbock’s disease has been reported. Ulnar minus variance is frequent in both diseases. Carpal slip is often found in multiple hereditary osteochondromata.
TREATMENT OF KEINBOCK’S DISEASE

Conservative Treatment

Immobilization is plaster cast has been tried in all stage of Keinbock’s disease. Lichtmann et al reported a series of 22 patients treated by the method. 17 of them had progressive collapse and 19 had unsatisfactory results.

Immobilization is indicated in Stage I cases in a hope that vascular insult be kept to the minimum to allow lunate to heal. It does not have any role in other stages of Keinbock’s disease.

Surgical Treatment

Joint leveling procedures

Joint leveling procedures have been advocated on the basis of theory of ulnar minus variance in the key etiology of Keinbock’s disease. These procedures aim equalization of the distal articular surfaces by either ulnar lengthening or radial shortening. Both of these procedures have had good results reported. Both these procedures were first described by Persson. However its role in advanced disease is doubtful.

Both these procedures require osteotomy. A segment of bone is removed when radial shortening is done and a segment of bone graft inserted when ulnar lengthening is done. After either procedure, fixation usually accomplished with a compression plate. It is generally recommended that the ulnar variance be changed to 1 to 2 mm positive variance by placing a appropriate sized inter positional graft during ulnar lengthening.

Radial shortening may be preferable to some because it does not require a second surgical incision to harvest the bone graft. Almquist and Burns obtained good results in 11 out of 12 patients (minimum follow of 5 years). Similar good results were reported by other authors like Oveson J (1981), Rock et al in 1991, Schattenkerk et al in 1987, Nakamura (1990), Weiss et al (1991).

Nakamura et. al., in an MRI study of patients with Keinbock’s disease treated non operatively and operatively by radial shortening and radial wedge osteotomy found evidence of revascularization in those cases treated by radial osteotomy. But they found no correlation between the signal intensity in MRI and clinical outcome.

Radial Wedge Osteotomy

Tsumara et. al.,(13) and Kojima et. al.,(14) proposed lateral closing wedge osteotomy
for Keinbock’s disease. The aim of the osteotomy was to reduce the radial inclination which shifted the loading vector to the radial side. The radiocarpal joint is radially deviated. To keep the wrist straight the patient is forced to ulnar deviate the wrist. This automatically improved the scaphoid rotation.

Kam et al. and Werner et al. after biomechanical analysis found that lateral opening wedge osteotomy is more effective than lateral closing wedge osteotomy in reducing the lunate strain.

Metaphyseal Core Decompression

Aldo A Illarramendi et al. described a new operation of radial and ulnar metaphyseal core decompression in the treatment of Keinbock’s disease. Through a small window in the metaphysis of radius and ulna the metaphyseal cancellous bone is curetted and reimpacted. They reported good results with 20 out of 22 patients returning to their prior occupation.

Revascularization Procedures

In Stage II Keinbock’s disease, before the lunate has collapsed, it is possible for the bone to regain blood supply. Braun has described a revascularization technique using pronator quadratus muscle pedicle graft.
The graft is based on the anterior interosseous artery. He transferred a portion of pronator quadratus with its underlying osseous insertion in the distal radius. As it is not conceivable that the lunate, once it has collapsed, could re-expand to its original size and shape, procedure designed to re-establish the vascularity must be performed early in the course of the disease. Neovascularisation procedure, if selected, should be reserved for patients with Stage I, II or early Stage III Keinbocks disease.

**Reconstruction and Revascularization**

Gabl et. al., from Austria treated 18 patients in stage III disease with debridement of necrotic lunate and implantation of free vascularised Iliac crest bone graft. They got satisfactory results in 16 out of 18 patients.
Free vascularised iliac bone graft

Excision Arthroplasty

Lunate excision was one of the first surgical procedures described for Keinbock's disease. The rationale for this procedure is to remove sequestered bone that is provoking painful synovitis. Nahigean and colleagues combined simple excision with dorsal capsular flap arthroplasty to prevent migration of capitate and reported good result. Schmitt and colleagues have reported a similar technique of capsuloplasty using ‘epitendinous’ tissue from flexor tendons to fill the gap. Another similar technique is excisional arthroplasty and replacement with a rolled tendinous graft of palmaris longus. This is performed much like the procedure of metacarpotrapezoidal joint Arthroplasty described by Froimson. Ishiguro also reported on the use of autogenous tendon graft, generally palmaris longus, plantaris or portion of flexor carpi radialis.

Replacement Arthroplasty

More recently Kato and colleagues has come up with silicone replacement Arthroplasty, or a “coiled palmaris longus tendon” for late stage II Keinbock’s disease, once the carpal collapse has occurred. Soft tissue replacement arthroplasty” or silicone replacement arthroplasty is simply another way to prevent migration following lunate excision. After excision, the lunate may be replaced by a hand carved Silastic wafer or more commonly by a Swansons design carpal lunate manufactured from high performance silicone elastomer. SRA is indicated in stage IV disease, once panchephalal arthritis is present. The deeper concavity for capitate articulation and the more anatomic design of the newer implant have reduced the risk of dislocation.

The advantages of SRA include rapid rehabilitation and return to work. It is also technically an easy operation to perform and it does not require a second operation. Silicone synovitis is seen in young active patients, patients with preoperative cysts and or degenerative changes, patients who had temporary Kirschner wire or suture fixation of the implant due to post operative implant instability. Therefore, SRA should not be done in young patients with extreme functional demands or in patients with dorsal carpal intercalary segment instability (DISI) unless it is combined with a procedure that reduces the bearing and shear stress forces and concomitant microfragmentation of the implant surface like leveling procedures or limited carpal arthrodesis. Furthermore, the surgeon must avoid Kirschner wire or suture fixation of implant and must achieve the intra operative stability of the lunate implant.

Limited Intercarpal Fusion

Arthrodesis of the lunate to adjacent carpal bones for advanced Keinbock disease presumably stage III or IV has been tried. Its most important advantage is that radio
carpal motion is maintained unlike total wrist arthodesis. Patients with severe fragmentation of the lunate undergo resection of the necrotic bone, osteotomy of the capitate in its midportion and proximal displacement of the proximal capitate fragment which is secured to the scaphoid and triquetrum with bone pegs. Essentially, the space created by the excision of the lunate is filled by proximal half of capitate, and the space left by the osteotomy of the capitate is filled by autogeneous bone graft. The procedure is then completed by performing arthrodesis of cartilaginous surfaces of the hamate, capitate, scaphoid and triquetrum. Capito-hamate fusion advocated by Chuinar and Zeman in 1980 prevents the proximal migration of capitate and decompress the lunate. It is indicated in early stages before collapse of the lunate. It can be combined with lunate replacement in late cases.

Scapho lunate fusions – Another limited intercarpal fusion, increases the lunate blood supply. A high percentage of non union has been reported with this technique.

Triscaphoid Fusion
Described by Watson in 1984. fusion of scaphoid, trapezium and trapezoid. This procedure should be reserved for patients with a significant scapholunate dissociation and DISI deformity preoperatively.

Salvage Procedures
1. Proximal row carpectomy
2. Arthrodesis of wrist
3. Total wrist arthroplasty
4. Denervation of wrist joint

For severe Keinbocks disease stage IV good results have been reported from proximal row carpectomy and wrist arthrodesis. Both these procedures have good short term results but arthritic changes have been described later. Denervation of wrist joint has been described by several authors to be successful in relieving pain without impairing function or mobility. Total wrist Arthroplasty has been tried in those cases with severe arthritis of wrist joint

CONCLUSION
Among various treatment advocated for Keinbocks disease it is apparent that no single treatment stands out as the best. Choice of treatment must be predicted on the experience of the surgeon, the desires, activity level, and goals of the patient; and the stage of the disease. SRA has constantly yielded good results in both stage II and III, but growing concerns and silicon synovitis and progressive cystic degeneration in contiguous bones make it inadvisable as a sole procedure in the young patient with carpal instability or in the patient who will have great functional demands. The other significant risk with SRA is the complication of implant dislocation. This is avoided by proper implant size, preservation of the lunate volar shell of bone along with its soft tissue attachments and careful suture of the dorsal capsule. The pronator muscle pedicle flap is a tedious procedure requiring fastidious attention. It is important to relieve the pronator fascia sufficiently in order to ensure adequate length of the muscle and to prevent its vascular compromise. Dislodgment of the graft has also been reported, and if one is using pull-out wires.

Radial shortening and ulnar lengthening are relatively simple procedures with good results in stage II and early stage III. With radial shortening, non-union of radius is possible. Furthermore, a second operation is required for implant removal. These procedures should not be done in the presence of significant collapse of lunate, as they are unlikely to restore lunate height and normal carpal kinematics. Their application in patients with netural and positive ulnar variance is questionable.
Overlengthening of the ulna may be a cause of post operative discomfort. Limited intercarpal arthrodesis may lead to marked limitations of range of motion. Triscaphoid arthrodesis may overcorrect the scaphoid rotation which may affect range of motion. Though a large number of surgical procedures have been described none seems to be a predictable solution to the problem of Keinbock’s disease.

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Figure Ulnar lengthening

Nakamura et. al., in an MRI study of patients with Keinbock’s disease treated non operatively and operatively by radial shortening and radial wedge osteotomy found evidence of revascularization in those cases treated by radial osteotomy. But they found no correlation between the signal intensity in MRI and clinical outcome.

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Kam etal and Werner etal after biomechanical analysis found that lateral opening wedge osteotomy is more effective than lateral closing wedge osteotomy in reducing the lunate strain.
Metaphyseal Core Decompression

Aldo A Illarramendi et al. described a new operation of radial and ulnar metaphyseal core decompression in the treatment of Keinbocks disease. Through a small window in the metaphysis of radius and ulna the metaphyseal cancellous bone is curetted and reimpacted. They reported good results with 20 out of 22 patients returning to their prior occupation.

Revascularization Procedures

In Stage II Keinbocks disease, before the lunate has collapsed, it is possible for the bone to regain blood supply. Braun has described a revascularization technique using pronator quadratus muscle pedicle graft.

The graft is based on the anterior interosseous artery. He transferred a portion of pronator quadratus with its underlying osseous insertion in the distal radius. As it is not conceivable that the lunate, once it has collapsed, could re-expand to its original size and shape, procedure designed to re-establish the vascularity must be performed early in the course of the disease. Neovascularisation procedure, if selected, should be reserved for patients with Stage I, II or early Stage III Keinbocks disease.
Reconstruction and Revascularization

Gabl et. al., from Austria treated 18 patients in stage III disease with debridement of necrotic lunate and implantation of free vascularised iliac crest bone graft. They got satisfactory results in 16 out of 18 patients.

Free vascularised iliac bone graft

Excision Arthroplasty

Lunate excision was one of the first surgical procedures described for Keinbock’s disease. The rationale for this procedure is to remove sequestered bone that is provoking painful synovitis. Nahigean and colleagues combined simple excision with dorsal capsular flap arthroplasty to prevent migration of capitate and reported good result. Schmitt and colleagues have reported a similar technique of capsuloplasty using ‘epitendinous’ tissue from flexor tendons to fill the gap. Another similar technique is excisional arthroplasty and replacement with a rolled tendinous graft of palmaris longus. This is performed much like the procedure of metacarpotrapezeal joint Arthroplasty described by Froimson. Ishiguro also reported on the use of autogenous tendon graft, generally palmaris longus, plantaris or portion of flexor carpi radialis.

Replacement Arthroplasty

More recently Kato and colleagues has come up with silicone replacement Arthroplasty, or a “coiled palmaris longus tendon” for late stage II Keinbock’s disease, once the carpal collapse has occurred. Soft tissue replacement arthroplasty” or silicone replacement arthroplasty is simply another way to prevent migration following lunate excision. After excision, the lunate may be replaced by a hand carved Silastic wafer or more commonly by a Swansons design carpal lunate manufactured from high performance silicone elastomer. SRA is indicated in stage IV disease, once pancerpal arthritis is present. The deeper concavity for capitate articulation and the more anatomic design of the newer implant have reduced the risk of dislocation.

The advantages of SRA include rapid rehabilitation and return to work. It is also technically an easy operation to perform and it does not require a second operation. Silicone synovitis is seen in young active patients, patients with preoperative cysts and or degenerative changes, patients who had temporary Kirschner wire or suture fixation of the implant due to post operative implant instability. Therefore, SRA should not be done in young patients with extreme functional demands or in patients with dorsal carpal intercalary segment instability (DISI) unless it is combined with a procedure that reduces the bearing and shear stress forces and concomitant microfragmentation of the implant surface like leveling procedures or limited carpal
arthrodesis. Furthermore, the surgeon must avoid Kirschner wire or suture fixation of implant and must achieve the intra operative stability of the lunate implant.

**Limited Intercarpal Fusion**

Arthrodesis of the lunate to adjacent carpal bones for advanced Keinbock disease presumably stage III or IV has been tried. Its most important advantage is that radio carpal motion is maintained unlike total wrist arthrodesis. Patients with severe fragmentation of the lunate undergo resection of the necrotic bone, osteotomy of the capitate in its midportion and proximal displacement of the proximal capitiate fragment which is secured to the scaphoid and triquetrum with bone pegs. Essentially, the space created by the excision of the lunate is filled by proximal half of capitate, and the space left by the osteotomy of the capitite is filled by autogeneous bone graft. The procedure is then completed by performing arthrodesis of cartilaginous surfaces of the hamate, capitite, scaphoid and triquetrum. Capito-hamate fusion advocated by Chuinar and Zeman in 1980 prevents the proximal migration of capitite and decompress the lunate. It is indicated in early stages before collapse of the lunate. It can be combined with lunate replacement in late cases.

**Triscaphoid Fusion**

Described by Watson in 1984. fusion of scaphoid, trapezium and trapezoid. This procedure should be reserved for patients with a significant scapholunate dissociation and DISI deformity preoperatively.

**Salvage Procedures**

1. Proximal row carpectomy
2. Arthrodesis of wrist
3. Total wrist arthroplasty
4. Denervation of wrist joint

For severe Keinbocks disease stage IV good results have been reported from proximal row carpectomy and wrist arthrodesis. Both these procedures have good short term results but arthritic changes have been described later. Denervation of wrist joint has been described by several authors to be successful in relieving pain without impairing function or mobility. Total wrist Arthroplasty has been tried in those cases with severe arthritis of wrist joint.

**CONCLUSION**

Among various treatment advocated for Keinbocks disease it is apparent that no single treatment stands out as the best. Choice of treatment must be predicted on the experience of the surgeon, the desires, activity level, and goals of the patient; and the stage of the disease. SRA has constantly yielded good results in both stage II and III, but growing concerns and silicon synovitis and progressive cystic degeneration in contiguous bones make it inadvisable as a sole procedure in the young patient with carpal instability or in the patient who will have great functional demands. The other significant risk with SRA is the complication of implant dislocation. This is avoided by proper implant size, preservation of the lunate volar shell of bone along with its soft tissue.
attachments and careful suture of the dorsal capsule. The pronator muscle pedicle flap is a tedious procedure requiring fastidious attention. It is important to relieve the pronator fascia sufficiently in order to ensure adequate length of the muscle and to prevent its vascular compromise. Dislodgment of the graft has also been reported, and if one is using pull-out wires.

Radial shortening and ulnar lengthening are relatively simple procedures with good results in stage II and early stage III. With radial shortening, non-union of radius is possible. Furthermore, a second operation is required for implant removal. These procedures should not be done in the presence of significant collapse of lunate, as they are unlikely to restore lunate height and normal carpal kinematics. Their application in patients with natural and positive ulnar variance is questionable. Overlengthening of the ulna may be a cause of post operative discomfort. Limited intercarpal arthrodesis may lead to marked limitations of range of motion. Triscaphoid arthrodesis may overcorrect the scaphoid rotation which may affect range of motion. Though a large number of surgical procedures have been described none seems to be a predictable solution to the problem of Keinbocks disease.

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