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A Comparative Study of Adams-Berger and Sauve-Kapandji Procedure in Chronic Distal Radio-Ulnar Joint Instability

Dr. Gourab Chatterjee[1], Dr. Sirshendu Kheto[2], Dr. Soumyadeep Dutta Roy[3], Dr. Sudipta Samanta[4]

[1] Assistant Professor, Department of Orthopaedics, Nil Ratan Sircar Medical College and Hospital

[2]Junior resident, department of Orthopaedics, Nil ratan Sircar medical College and Hospital

[3]Assistant Professor, Department of Orthopaedics, Nil Ratan Sircar Medical College and Hospital

[4]Junior resident, department of Orthopaedics, Nil ratan Sircar medical College and Hospital

Corresponding Author Email: *dr.gourabchatterjee[at]gmail.com*
Contact: +916291020482/ +919432957376

Abstract: ***Introduction*: Distal radio-ulnar joint instability results from a variety of factors including trauma to the joint. In most of the cases patients presented with ulnar sided wrist pain and instability as well as reduced grip strength. In literature many of the procedures has been demonstrated to address the disorders of distal radio-ulnar joint. Our study aims to compare the outcomes of Sauve-kapandji procedure with Adams-berger procedure in cases of distal radio-ulnar joint instability. *Materials and methods*: Our study is a prospective study done in the outpatient department of our institution. We included patients with chronic distal radio-ulnar joint disorder and excluded other causes of global or ulnar wrist pain. Then we studied the subjects in terms of clinical, radiological and functional parameters. *Results*: Ulnar sided wrist pain (75%) was the most prevalent clinical symptom among the patients. Press test (75%) was the most prevalent positive clinical test followed by ulnar impaction test (68.75%) among the patients.31% patients had Triangular fibrocartilagenous Complex injury comprising of 2 dorsal radioulnar ligament injury, 2 palmer type 1A injury with central perforation and the 1 volar radio-ulnar ligament injury. Mean ulnar variance in sauve-kapandji procedure group was 2.8 ± 0.5 mm and in the Adams-berger group was 2.6 ± 0.89mm. Improvement of grip strength occurred in both the groups but it was not significant. In either group, 3 out of 8 (37.5%) patients ended up having no movement restriction at final followup. *Conclusion*: We conclude that Adams-berger procedure is superior to Sauve-Kapandji procedure.***

Keywords: Adams-berger procedure, Distal Radio-ulnar joint, Sauve-kapandji procedure, Wrist Pain

1. Introduction

Distal radio-ulnar joint (DRUJ) is comprised of the sigmoid notch of the radius articulating with the ulnar head and supported by the ligaments and triangular fibrocartilagenous complex (TFCC). TFCC comprises of 6 main and different anatomical structure namely dorsal and volar raioulnar ligament, the articulating disc, the meniscal analogue, the ulnotriquetral ligament, ulnolunate ligament, ulnar collateral ligament and extensor carpi ulnaris (ECU) sheath[1, 2]. The major factor providing stability to DRUJ is the dorsal and volar radio-ulnar ligament; the articular surface congruity comprising of only 20% of the stability[1, 3]. Overall, the stabilisers of DRUJ can be divided into dyna, ic and static. Dynamic stabilisers are ECU tendon sheath and pronator quadratus where as static stabilisers are the ligamants along with articular congruity[4]. As we mentioned earlier the distal radioulnar ligaments are the strongest static stabiliser of DRUJ. Both the distal radioulnar ligaments have a deep and superficial part. The deep part receives attachhment at fovea and the superficial part receives attachment to tip of styloid process.

The disorders of DRUJ can be classified in four different groups namely impaction, incongruity, inflammation and instability[5]. All of these conditions produce pain at the ulnar aspect of the wrist and subsequent evaluation may find one or more pathology.

Ulno-carpal impaction is a cause of ulnar sided wrist pain. This should be differentiated from ulno-styloid impaction syndrome. This differentiation can be done clinically by eliciting pain in ulnar deviated wrist with forearm in supination for the latter and forearm in pronation or neutral rotation for former[1]. Positive ulnar variance is a common physiologic finding but may be associated with developmental anomalies like madelung deformity. Acquired causes of positive ulnar variance include shortening of radius following distal radius fracture, radial head fracture-dislocation (Essex-Lopresseti lesion), traumatic growth arrests of distal radius[1]. Sauve-Kapandji procedure involves ulnar shortening osteotomy with DRUJ arthrodesis. This procedure is a salvage to ulnar sided painful wrist and helps to maintain ulnar support of the wrist. Lamey and Fernandez modification of sauve-kapandji procedure eliminates the problems arising from the proximal ulnar instability[1, 6].

Adams-Berger procedure involves anatomical DRUJ reconstruction. It is indicated in symptomatic DRUJ instability due to irrepairiable TFCC lesions[1, 7]. Patients with a TFCC injury typically has a history of fall on outstretched hand along with ulnar sided wrist pain and mechanical

symptoms improving with rest and worsening with activity as well as weakness of the grip[1]. A painful click may be elicited by having the patient clench and ulnarly deviate the wrist and then repeatedly pronate and supinate the wrist. Other tests which may be positive in TFCC injury includes ulnar impaction test (wrist hyperextension and ulnar deviation with axial compression), press test, piano-key sign[1]. In case where TFCC cannot be repaired, sigmoid notch congruity is not hampereed' the reconstruction of ligamanets around distal radio-ulnar joint may improve the joint stability satisfactorily.

Our study aims to compare the clinical and functional outcome of Adams-berger procedure to Sauve-Kapandji procedure in chronic DRUJ instability.

2. Materials and Methods

a) Study design: Prospective Study
b) Study Area: Department of orthopaedics, NRS Medical College and Hospital
c) Study Population: Patients with chronic DRUJ disorder
d) Study Duration: From March 2022 to January 2023
e) Sample Size: Total 16 patients with Chronic DRUJ disorder stratified in Sauve-Kapandji Procedure group (Group A) and Adams-Berger Group (Group B) with 8 patients in each group.
f) Study Tools: Xray, CT scan, MRI (Whenever needed), Orthopaedic implants as and when needed, Goniometer, Dynamometer
g) Inclusion Criteria:
- Patients aged more than 18 yrs
- Chronic DRUJ instability presenting with ulnar sided wrist pain or global wrist pain or instability
- Radiological evidence of DRUJ disorder

h) Exclusion Criteria:
- Other pathology which may cause ulnar sided wrist pain other than chronic DRUJ disorder
- Inflammtory arthritis such as Rheumatoid arthritis
- Recent trauma
- Acute or chronic infection
- Benign or malignant neoplastic pathology e. g. Giant cell tumor, osteosarcoma etc.

i) Parameters to be studied:
Clinical:
- Pain during supination and pronation of the wrist joint in terms of daily activity
- Cosmetic Deformity (ulnar head prominence at the dorsum while doing movements)
- Grip strength

Radiological:
- Presence of Ulnar variance (Measured in milimeters)
- Integrity of DRUJ articulation with the help of axial and sagittal cut of 3-D CT scan and MRI to evaluate ligamentous integrity

j) Functional:
- VAAS Score to objectify the pain
- MMWS (Modified Mayo Wrist score)

k) Study Technique:
All patients complaining of global or ulnar sided wrist pain attending at outdoor of NRS Medical College and hospital has been clinically examined and enquired. Relevant blood investigations and radiological investigations were done to rule out any inflammatory arthritis, infection or any benign or malignant neoplastic etiology. Enquiry about any past history of trauma was done. Routine radiographs obtained which showed the wrist with radio-ulnar and radio-carpal articulations in postero-anterior, lateral, pronated grip view. In the routine PA view xray of wrist we calculated the 'ulnar variance' in following method.

l) Method of calculating Ulnar variance:

Line A represents the line through longitudinal axis of radius. Line B represents the line perpendicular to line A passing through distal ulnar articulating surface. Line C represents the line perpendicular to line A passing through the distal radius articular surface through the ulnarmost corner of sigmoid notch.

Ulnar variance = the distance between line B and line C.

Categorising the patients according to the degree of ulnar variance is done as following:
Positive ulnar variance = >2.5mm
Neutral Ulnar Variance= 1-2.5mm
Negative ulnar Variance = <1mm
As we classified the subjects according to the degree of ulnar variance we also kept a note that what was the cause.

Identifying TFCC injury:
TFCC injuries are suspected in patients with ulnar sided wrist pain with a history of fall on the outstretched hand. Patients with TFCC injury may demonstrate positive ulnar impaction test, positive press tes; wrist in hyperextension and ulnar deviation produces pain while axial loading is

done. Other than these two tests we also sought for piano key sign where the distal ulnar head sublaxates on volar directed pressure from dorsal aspect in a fully pronated well supported wrist. We investigated suspected TFCC injuries with the help of MRI and if any TFCC injury has been identified we classified it according to Palmer classification (Appendix 1)

Sorting into groups and Overview of Surgical Procedures:

All 16 patients, gathered from the outdoor with chronic DRUJ disorder according to our inclusion and exclusion criteria has been grouped into two-Group A namely the Sauve-Kapandji Group and Group B namely the Adams-Berger group.

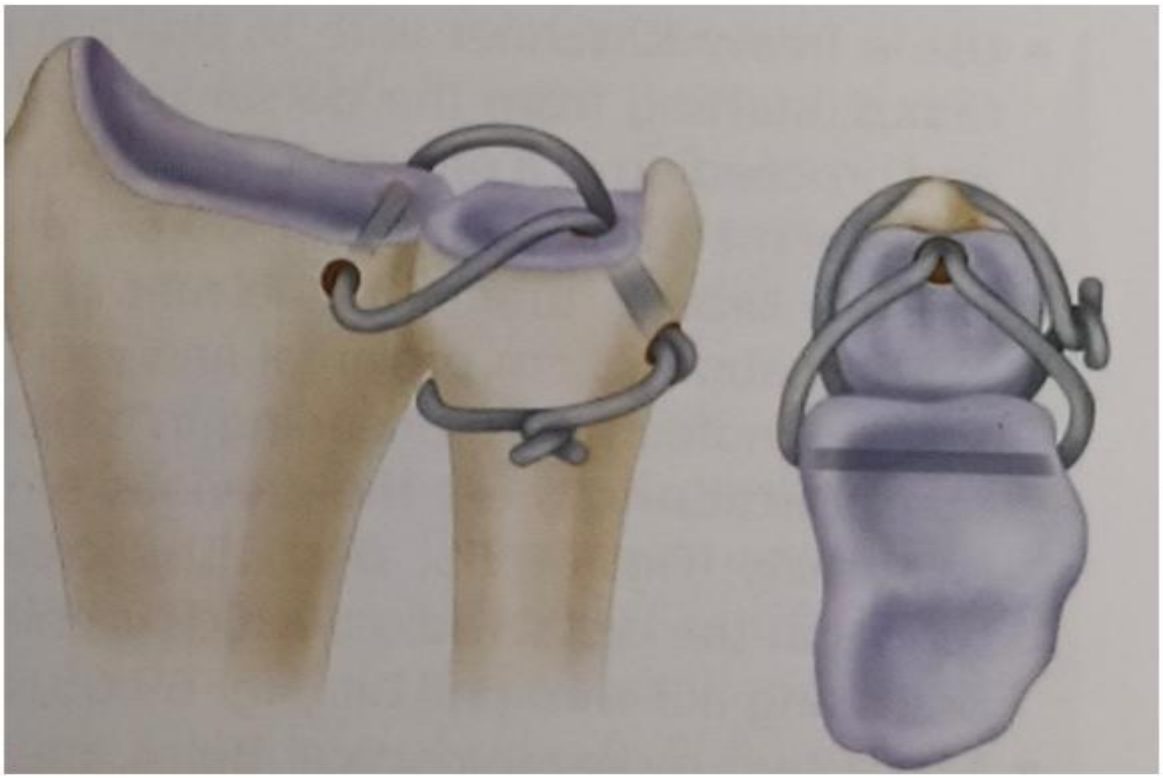
Adams-Berger Procedure:

A 4-cm dorsal skin incision between the fifth and sixth extensor compartments was made. The fifth compartment was opened and the extensor digiti quinti (EDQ) tendon was retracted. The DRUJ was exposed with an L-shaped capsular incision along the dorsal rim of the sigmoid notch, parallel to the native location of the dorsal radioulnar ligament. The DRUJ and TFCC were then evaluated.

To determine the distal radius bone tunnel position, a guide wire was placed under fluoroscopic guidance 4 to 5 mm proximal to the lunate fossa and radial to the sigmoid. A 3-cm palmar skin incision was made between the ulnar neurovascular bundle and digital flexor tendons proximal to the proximal wrist crease. The flexor tendons were retracted radially and the neurovascular bundle ulnarly to identify the volar aspect of the bone tunnel. The guidewire was then overdrilled using a cannulated 3 to 3.5mm drill bit and an awl was used to widen the tunnel to allow graft passage. Using the same cannulated drilling technique, a second oblique bone tunnel was made in the distal ulna by drilling retrograde from the fovea to the ulnar aspect of the ulnar shaft. A suture retriever was then passed through the radial tunnel from dorsal to volar and a limb of either an autologous or cadaveric tendon graft was passed dorsally. Choice of tendon (allo vs. autograft) was left to the discretion of the surgeon. The palmaris longus tendon can be of inadequate length for the conventional method of a half-hitch, and thus an allograft may be beneficial. A hemostat was directed from dorsal to volar just distal to the ulnar head and proximal to any remnants of the TFCC and pushed through the volar DRUJ capsule to grasp the palmar limb of the graft. The graft was pulled dorsally and tightened, ensuring not to trap any volar structures.

Both limbs of the graft were passed through the ulnar tunnel. One limb was passed underneath the extensor carpi ulnaris sheath, while the other limb was passed in the opposite direction, with attention not to entrap the ulnar neurovascular bundle. With manual compression applied to a neutral-positioned DRUJ, a half-hitch was made with the two limbs of the graft, pulled tight and then secured with nonresorbable sutures while maintaining graft tension. The dorsal DRUJ capsule and extensor retinaculum were closed in layers to add additional stability. To add further stability, the tendon graft may be incorporated into the capsular repair. The EDQ was left transposed and bowstringing was prevented by keeping the distal part of the extensor retinaculum intact.

If an interference screw was preferred for graft fixation, the DRUJ was manually compressed in neutral position and both limbs of the graft were pulled tight at the proximal opening of the ulnar bone tunnel. The interference screw was advanced in a proximal to distal direction, providing a solid fixation of the graft in the bone tunnel. If bone-anchored sutures were used, two anchors were inserted just proximal to the ulnar tunnel and horizontal mattress sutures were used to secure the graft after a half hitch of the two limbs. Pinning of the ulna to the radius is optional and is independent of the method of graft fixation. In our opinion, pinning should not be necessary following closure of the capsule but could be considered if residual instability is present or due to concerns regarding patient compliance.



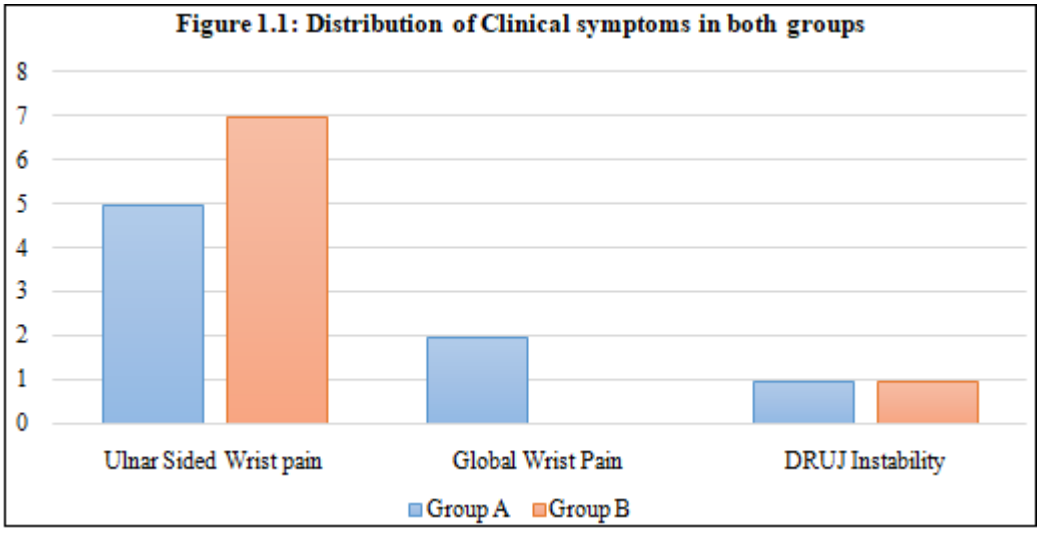
In our study, we routinely used a ulno-radial K wire to stabilise the DRUJ after anatomical reconstruction. This has been followed up with above-elbow slab kept ex-situ for 6 weeks. The slab has been changed only twice while dressing and stitch off followed by reapplication of the slab.

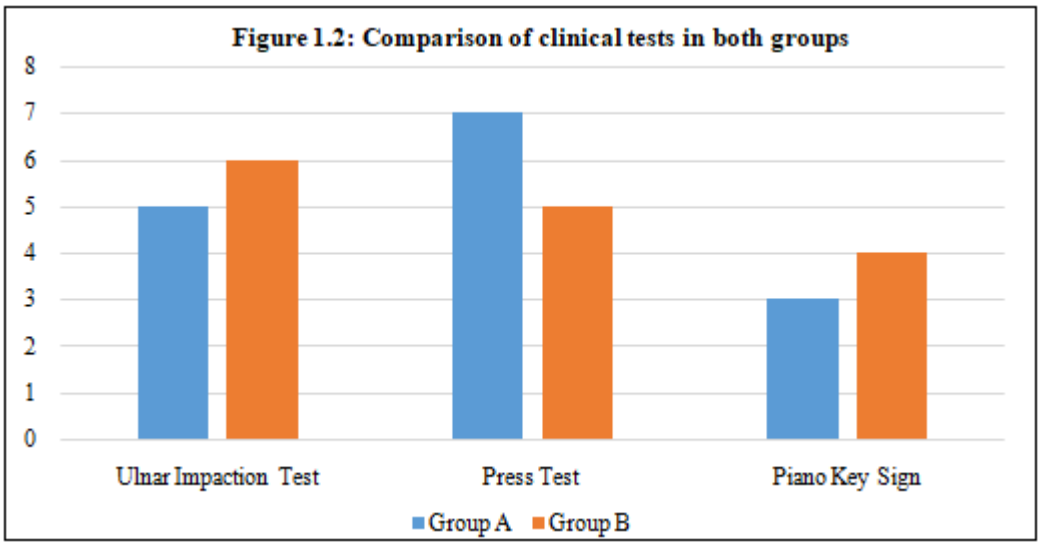
Sauve-Kapandji Procedure:
Sauve-Kapandji procedure is done through a dorso-ulnar incision centring on ulnar head and working through the interval of extensor carpi ulnaris and extensor digiti minimi. Extensor retinaculum is opened and a proximal laterally based flap and a distal ulnar based flaps have been raised which can be reattached at the end of the procedure or can be discarded later. Temporary stabilisation of DRUJ with a 1.8mm K-wire is done followed by ulnar shortening osteotomy proximal to ulnar neck and DRUJ with an oscillating saw. After the significant length of bone being removed to correct the ulnar variance, the temporary stabilisation is removed and definitive stabilisation with a 3.5mm cortex screw is done under image intensification. We used washer if the bone quality is suspected to be poor. We used the screw at the distal most end of the ulna. Proximal ulnar stump instability has been corrected by attaching the pronator quadratus from the excised ulnar segment. We routinely didn't follow Lamey-Fernandez modification of sauve-kapandji procedure by attaching Flexor Carpi Ulnaris tenodesis with proximal ulnar segment.

A) Statistical Analysis:
We formulated a master chart in MS Excel containing all the patient details. We categorised them in demographic parameter, clinical, radiological parameter etc. Continuous variables and categorical variables were compared using nonparametric tests. All tests were two sided. Statistical significance level was set to 0.05.

3. Results

A) Comparison of Clinical symptoms and signs:
As we enquired about the clinical symptoms, we found that there were basically three category-ulnar sided wrist pain, global wrist pain, instability. We have found that in Group A 5 patients had ulnar sided wrist pain where as in group B 7 patients had ulnar sided wrist pain. The result has been summarised in table 1. Most of the ulnar sided pain was associated with ulnar deviation and axial loading of the affected wrist typically complained while driving or getting up from a sitting position with support on the table or chair. The instability is complained as prominence of ulnar head while pronating the forearm.





B) Comparison of TFCC injury in both groups:
As mentioned earlier, we routinely evaluated TFCC injury in patients where chronic DRUJ disorder has been suspected. We performed MRI with gadolinium contrast to identify TFCC injury and the result has been shown in figure 2. Out of all TFCC injuries, 2 patients had dorsal radioulnar

ligament injury, 2 had palmer type 1A injury with central perforation and the last person had volar radio-ulnar ligament injury.4 of these patients belong to group B where as the rest belongs to group A.

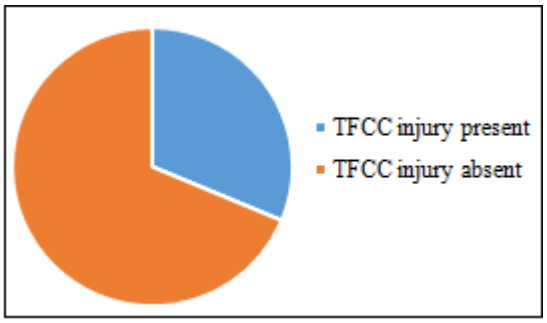


Figure 2: Incidence of TFCC injury in both groups

C) Comparison of Improvement of pain in post-operative patients in each group:

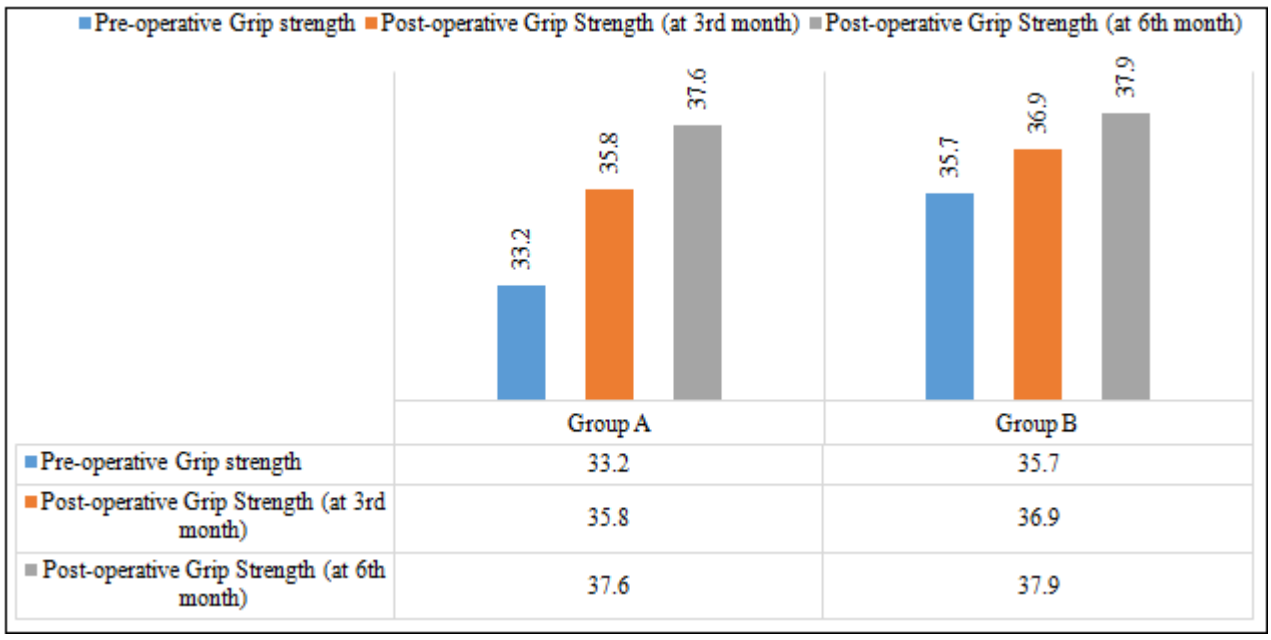
Before proceeding to operations in each group we tried conservative methods like NSAID group of medications to improve the pain which failed to show any improvement. In immediate post-operative periods the pain was significantly more, which we believe because of operation. However, as we kept following up, at 3rd and 6th month followup of the patients showed significant pain relief from their initial presentation. However, 3 patients from group B complained of pain at the ulnar aspect over the surgical inicision while pronation-supination. But the symptoms relieved by low dose analgesics given as and when required.2 patients from group A complained same and it also relieved with conservative measures like hot compression and low dose oral analgesic.

D) Comparison of Ulnar Variance:

As we compared the ulnar variance in both the groups, we have found mean ulnar variance in sauve-kapandji procedure group was 2.8 ± 0.5 mm and in the Adams-berger group was 2.6 ± 0.89mm.

E) Comparison of Grip Strength:

Grip strength was measured by the dynamometer. We took three values consecutively with the dynamometer in each of the patients of both groups. Each patient had three separate values of affected and non-affected wrist. We compared the grip strength of non-affected wrist with affected wrist in each patient after they underwent our surgical procedure. The figure 3 summarises our finding (grip strength is measure in kilograms as mean ± s. d).



F) Comparison of Daily activities pre-operatively and post-operatively in both groups at 6 monthly follow-up:

All patients in either group had some degree of restriction in their day to day activity. We compared their pre-operative details to their post-operative details in each group. The results are summarized in table 1.

Table 1

Degree of Activity	Group A	Group B
No restriction	3	3
Minimal restriction felt while doing outside daily activity	2	1
Significantly restricted (No improvement)	0	0
Minimal discomfort while pronation-supination	3	2
N (total)	8	7

G) Complications in each group:

The complications we observed has been divided in to two groups. The first group comprises of general surgical complications like wound infection with or without dehiscence etc. The second group comprises of complications specific to the procedure. For sauve-kapandji procedure specific complication includes-nonunion or delayed union of arthrodesis, painful instability of proximal ulna stump. Specific complications related to Adam-Berger procedure includes ulnar nv neuropraxia, graft failure, persistent symptomatic DRUJ instability, painful degenerative arthritis of DRUJ. Table 2 summarizes our finding at immediate post-operative, at 3monthly and at 6 monthly interval.

Table 2: Complications in each group

Complications		Group A	Group B
Surgical Site Infection		3	1
Non union of arthrodesis	3rd postop month	0	N/A
	6th postop month	1	
Proximal Ulnar stump Instability	3rd postop month	0	N/A
	6th postop month	1	
Ulnar nerve Neuropraxia	3rd postop month	N/A	0
	6th postop month		0
Graft failure	3rd postop month	N/A	0
	6th postop month		1
Painful Degenerative arthritis	3rd postop month	2	3
	6th postop month	4	5
Persistent DRUJ Instability	3rd postop month	0	1
	6th postop month	1	2

4. Discussion

Distal Radio-ulnar joint is crucial and performs the function of rotating radius around the stationary ulna while forearm supination-pronantion[7]. Rotation of the forearm takes place in both proximal and distal radio-ulnar joint. Due to geometry of the bones and that the ulnar head is smaller that the capacity of sigmoid notch of distal radius, movements taking place at DRUJ is essentially a sum of rotation as well as some degree of translation; whereas in PRUJ only pure rotatory movement takes place[1, 8]. Stability of DRUJ has been conferred by a multiple factors which include static and dynamic stabilisers. Weakness of these stabilisers can result from multiple reasons. Ulnar variance is one of the important factor to look upon to know about the DRUJ instability. Not only ulnar variance (positive ulnar variance) produces ulno-carpal abutment syndrome, but also positive ulnar variance sometimes lead to central or paracentral tear of TFCC (Palmer 1A). However, due to the role DRUJ plays in supination-pronation; any disorder of DRUJ may render a person incapable of carrying out day to day activities.

Adams-Berger described a technique of anatomical reconstruction of DRUJ[9, 10]. The aim of the procedure is to restore the kinematics of DRUJ by dorsal and volar radio-ulnar ligament reconstruction using a tendon graft. Indication of the procedure is irreplaceable TFCC injury with dorsal and volar ligament injury with or without DRUJ arthritis [10, 11]. Sauve-Kapandji Procedure, on the other-hand, relies on the distal ulnar shortening osteotomy with DRUJ arthrodesis.

As we compared the two procedures, we found that most patients with DRUJ disorder has ulnar sided wrist pain. Ulnar sided wrist pain has been associated with more specifically TFCC tear. Ulnar sided wrist pain correlated with ulnar deviated and hyper-extended wrist and pain felt on axial compression is highly suggestive of TFCC injury[1]. These groups of patients often complain of pain while forceful spinning of steering[4]. Diagnosis of DRUJ disorder is not an easy task and rely on multiple clinical tests to be performed namely, piano key sign, grind test, press test, ulnar impaction test etc. In our study we found out of all 16 patients, press test was found to be positive in 12 patients conferring a 75% sensitivity to the test. This data is somewhat low as shown by other studies[13, 14]. Wijjfels et al, demonstrated that piano key sign has 66% sensitivity whereas in our study it is of only 45%[13].

Indication of surgery in our study was symptomatic DRUJ disorder. Most common symptom we encountered was pain which was mostly ulnar sided but sometimes global pain has also been complained. Second to that patients complained of instability and a prominent ulnar head while supinating and pronating forearm. Some patients also complained of clunk. Press test was most prevalent positive finding in our study. Ulnar sided wrist pain has an incidence of 75% compared to other literatures[4]. Symptomatic instability has an incidence of 12.5% compared to 8% according to Gills et al[4].

Incidence of TFCC injury in DRUJ disorders has been 79% according to Lindau et al[15]. In a study conducted by Yan et al, 96.5% patients had TFCC injury with concomitant distal radius fracture[16]. According to Thomas et al[17], a series showed 43% incidence of overall TFCC injury among all DRUJ instability. As we evaluated incidence of TFCC injury in our study the incidence is found to be 31.25%. The wide variability of incidence of TFCC injury is probably due to the modality used to identify TFCC injury. MRI is 100% sensitive in detecting TFCC injury[1], but the interpreter reliability plays a confounding role while detecting TFCC injury by MRI.

Since most of the patients had a complaint of pain in the affected wrist joint, we evaluated the outcome in each group in terms of improvement of pain along with grip strength and their return to pre-injury activity. Most of the patients had improved pain but in group A we found incidence of post-operative pain is more than group B. We think this is probably because of implant associated irritation in Sauve-Kapandji procedure. Grip strength was better after Adams-berger procedure than sauve-kapandji procedure. This is probably due to the full ulnar support in Adams-berger group than sauve-kapandji group. As we compared to return to activity we found that comparable return to activity in both the groups and overall patient satisfaction was comparable. However, restricted prono-supination was more in group A than group B as also found out by literature[4].

Functional outcome of each procedure has been compared with the help pf DASH, MMWS scores. The questionnaires have been provided in appendix-2. The mean MMWS improved in all. Teoh et al, looked at nine patients who underwent anatomic DRUJ reconstruction at an average of 1.2 years short-term follow-up and 9 years long-term follow-up[18]. All patients had improvement in grip strength and wrist scores. The wrist scores decreased from the short-to the long-term follow-up period. Only three of nine patients remained pain free at long-term follow-up and two patients had recurrent instability[18]. Mean Dash score after Sauve-kapandji group 6 month post-operatively was 38 where as that after Adams-berger procedure was 35. This was in accordance with the finding of Giberson et al[19]. Functional outcome according to patient questionnaire was better in adams-berger group than sauve-kapandji group. Also this can be seen from the fact that post Adams-berger patients found less difficulty during range of motions of wrist after they return to their daily activity. However, the authors find it insignificant considering the number of study subjects were less so was the duration of follow up.

The complications in our study subjects were divided into two broad categories namely general complications attributed to both the groups and specific complications attributed to the specific procedure group. Superficial surgical site infection was found in 37.5% of the patients in group A whereas the incidence was found to be 12.5% in group B. All these patients underwent aseptic dressing sequentially and the infection subsided under intravenous antibiotic. At the time of discharge the wound was dry and uneventful recovery was expected.

In 1855, Malgaine[20], described ulnar head resection which was later modified by Darrach[21]. Despite being an easy procedure to perform with good functional results, loss of grip strength and instability of proximal ulna has been reported in literature. To circumvent the problems, surgical procedures preserving ulnar styloid was sought. Sauve-kapandji procedure has three specific complications as per literature are nonunion or delayed union of the arthrodesis, fibrous or osseous union at the pseudoarthrosis, and painful instability of the proximal ulna stump. To prevent painful ulnar stump instability, tenodesis using ECU or FCU tendon has been recommended in literature[1, 22, 23]. Lluch et al showed that best result is obtained by carrying out the pseudoarthrosis at the level of ulnar head[24]. In most of our patients, we carried a distal most pseudoarthrosis at the level of ulnar head in order to prevent proximal ulnar stump insatbility. This provides both static and dynamic stability as described by Lluch et al[22]. At 6th postoperative followup we dealt with 1 proximal ulnar stump instability. We also encountered secondary degenerative osteoarthritis which is probably due to wearing from implant positioning in 4 patients at 6th postoperative followup month.

Adam-Berger procedure group (group B) has separate group of complications. Ulnar nerve neuropraxia is a documented complication post Adams-berger procedure. We encountered no ulnar nerve neuropraxia in our pool of patients. However, reported incidence in literature in 6.3%[10]. Graft failure has been observed in 1 patient at 6th postoperative month followup. As per literature, graft failure is more seen in females compared to males and with usage of interference screw[10]. we did not use interference screw rather used suture anchors for the tendon. Kalson et al, tested different tendon fixation methods from biomechanics perspective and identified that maximum load to failure of the original suture method of tendon graft fixation is equal to that of loop anchor methods and both were superior to interference screw. Reasons of Interference screw failure can be explained by varying tension while tightening the screw or due to varying tunnel size in wrist which may not tolerate loads over time. Solid tendon to bone tunnel healing provides long term stability in Adams-Berger procedure[27]. The native enthesis is not regenerated in bone tunnel. Rather the stability of tendon graft in bone tunnel relies of new collagen fibre formation[28, 29, 30]. this is an important factor for the surgeon to consider. In our study, we followed protocol of 6 weeks immobilisation in a long arm slab as well as intra-operative ulno-radial K-wire fixation for DRUJ stability which has been well supported by literature[10].

Comparing overall complication rates, Adams-berger procedure has less complication rates compared to Sauve-kapandji procedure. However, our study subjects and followup duration was not enough to properly compare the outcomes of both the procedures.

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