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Radiological and functional outcome of distal radius fractures treated with cast vs. plate-a prospective study

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Abstract

Fractures at the distal end of radius are one of the most frequent fractures¹ encountered in the emergency department related to Orthopaedics. They have been treated since ages with closed manipulation and reduction, but maintaining reduction is a very difficult task, especially within a week after injury, after subsidence of swelling. Hence, in a majority of cases, casting gives a satisfactory reduction but can be lost, resulting in a poor anatomical and, in some cases, poor functional outcome. Displacement following conservative management with closed manipulation and casting, is an indicator of instability, and revision to correct the displacement by manipulation will not give a satisfactory alignment and thereafter resulting in poor functional outcome. Fractures at the distal end of the Radius, with displacement are considered unstable when alignment cannot be maintained after closed reduction in a plaster cast. For minimizing the loss of reduction in unstable distal radius fractures, various methods have been devised of which, Open reduction and internal fixation with plating provide better anatomical reduction and aids in early mobilization.

Aims and Objectives: To study the functional and radiological outcome in distal end of the Radius fractures managed with cast vs. plate.

Materials and Methods

Study Design: Hospital-Based Prospective study

Study period: November 2019 to October 2021

Study setup: Study will be conducted in Department of Orthopaedics, Andhra Medical College, Visakhapatnam.

Sample size: Number of patients, who sustained distal end of the radius fractures attending King George Hospital from November 2019 to October 2021 will be chosen.

Results: Both the treatment methods showed significant outcome at the time of post-intervention. While comparing the radiological parameters at 6th week and 6th month, casting group have more significant changes in radiological parameters than the plating group which indicates that plating helps in maintaining reduction better than casting. Mean DASH scores were compared in two groups at the end of six weeks and six months. At end of six weeks p-value was 0.33 (>0.05) and at end of six months p-value was 0.0048 (<0.05) indicating significant difference between two groups in terms of functional outcome at six months follow-up but not at six weeks follow-up.

Conclusion: Finally our study indicating that the plating is the best option for patients who are technically demanding and who wants an accelerated recovery of function while the casting is the best option for patients whose working capacities are sub-optimal and who is not in favour of any reoperation.

Keywords: Hip fracture, bone turnover markers, CTX, PINP, vitamin D

Introduction

Fractures at the distal end of radius are one of the most frequent fractures^[1] encountered in the emergency department related to Orthopaedics.

They have been treated since ages with closed manipulation and reduction, but maintaining reduction is a very difficult task, especially within a week after injury, after subsidence of swelling. Hence, in a majority of cases, casting gives a satisfactory reduction but can be lost, resulting in a poor anatomical and, in some cases, poor functional outcome.

Displacement following conservative management with closed manipulation and casting, is an indicator of instability, and revision to correct the displacement by manipulation will not give a satisfactory alignment and thereafter resulting in poor functional outcome.

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Fractures at the distal end of the Radius, with displacement are considered unstable when alignment cannot be maintained after closed reduction in a plaster cast. For minimizing the loss of reduction in unstable distal radius fractures, various surgical methods have been devised and include
 Percutaneous 'K' Wire fixation
 External fixator
 External fixator with augmentation with pins

Open reduction and internal fixation with plating which will provide better anatomical reduction and aids in early mobilization

Fragment and column-specific fixation.
 Combination fixations.

Aim of the study

To study the functional and radiological outcome in distal end of the Radius fractures managed with cast vs. plate.
 To study the fracture pattern and its relation to the restoration of distal radius anatomical and functional parameters after managed with cast vs. plate.
 To identify the potential factors, responsible for unsatisfactory outcomes in these two techniques of management.

Materials and Methods

Study Design: Hospital-Based Prospective study

Study period: November 2019 to October 2021

Study setup: Study will be conducted in Department of Orthopaedics, Andhra Medical College, Visakhapatnam.

Sampling design: Convenient sampling.

Sample size: Number of patients, who sustained distal end of the radius fractures attending King George Hospital from November 2019 to October 2021 will be chosen.

Study tools: X rays, DASH questionnaire functional score for the wrist, and CT scan if suspected intra-articular extension.

Inclusion criteria

Patients age more than 18 years (skeletally matured patients).
 Closed fractures at the distal end of Radius.
 Displaced extra-articular fractures.
 Simple intra-articular fractures.
 Patients with informed written consent.
 No history of previous surgery in the forearm/wrist.
 Patients present within two weeks of injury.

Exclusion criteria

Immature skeleton.
 Open fractures.
 Congenital deformities of the ipsilateral limb.
 Patients who are dependent on others for daily activities.
 Fractures associated with neurovascular injuries.
 Fractures associated with musculoskeletal injuries to ipsilateral limb.
 Fractures more than two weeks old.

Methodology

The Institute Ethics Committee approval was obtained.
 Written and Informed Consent was obtained from the Patient.
 Patient was subjected to General Physical Examination, Systemic Examination and forearm and wrist examination.
 Standard postero-anterior and lateral view x-rays were taken for affected and unaffected distal radii.
 Following parameters evaluated

1. Radial length
2. Radial inclination

3. Dorsal tilt
4. Ulnar variance
5. Metaphyseal comminution
6. Intra-articular step-off

During this period, patients who sustained distal end of the radius fractures, attending King George Hospital were chosen. They were randomly divided into two groups.

One group were treated conservatively with below elbow pop casing after closed manipulation and reduction under brachial plexus block or short general anaesthesia or local hematoma block.

Acceptable reduction criteria for distal radius fracture is

1. Radial shortening <5 mm at distal radio-ulnar joint
2. Radial angulation on postero anterior radiographs >15°
3. Tilt on lateral view in between 15° dorsal tilt to 20° volar tilt
4. Articular incongruence or gap <2mm of radio-carpal joint closed reduction with cast immobilisation group

Anaesthesia: Under brachial plexus block or general anaesthesia, or hematoma block, displaced fractures reduced by longitudinal traction and gentle manipulation. Traction was applied for dis-impaction of the bone surfaces; holding the thumb, index finger, and middle finger. Counter-traction is applied at the arm with flexed elbow of patient by an assistant. Translation reduction maneuvers will be used. With maintained traction at the fracture site, hand was palmar flexed and moved towards ulnar side, these maneuvers were applied to reduce the distal fragment. Finally the fracture was locked in reduced position by applying slight pronation, ulnar deviation and palmar flexion forces.

With this maintained reduction below elbow plaster slab was applied on the dorsal side of forearm. Molding of the splint using the three-point pressure technique should be done to lessen the chances of re-displacement. The patient was advised limb elevation with cuff and collar as a sling.

Post reduction standard postero-anterior and lateral x-rays were taken. If the reduction is inadequate, but the fracture configuration was intrinsically stable, re-manipulation was performed. The patients were observed for 48 hours to ensure that excessive swelling, neuro vascular compromise to be avoided.

Active finger movements was advised from day one. Once swelling subsides, slab was converted into the cast, usually around three to four days post- reduction. The wrist was brought to a neutral position after evidence of fracture healing, mostly around three to four weeks. Patients were encouraged for the "six pack" exercise regimen described by Dobyns and Linscheid atleast three times a day, along with elbow and shoulder mobilization. Patients were reviewed at 2nd week, 4th week. At this stage, fracture union was confirmed radiologically, and cast removal was done. Elastic-crepe bandage applied for a couple of weeks thereafter.

Patients are encouraged for wrist movements. Patients will be reviewed hereafter at 6thweek, 24thweek respectively. At the end of 6th and 24thweek, outcomes will be assessed.

Open reduction with plating group (Procedure)

Under brachial block/general anaesthesia, A 5-8cm incision is made over the flexor carpi radialis (modified Henry's approach) with a radially deviated incision at the wrist flexion crease.

Carry the incision down to the flexor carpi radialis tendon sheath protecting the superficial branch of the radial artery. Carry the incision distally to the trapezial ridge protecting the palmar cutaneous branch of the median nerve. The flexor carpi radialis anterior and posterior sheaths are incised enabling it to be retracted ulnarly.

Continue the incision distally cutting a leaflet of the transverse carpal ligament as well as developing the space of Parona. Perforators to the FPL (flexor pollicis longus) are coagulated and the flexor pollicis longus is retracted ulnarly.

The watershed line is identified by palpating the lunate fossa over the pronator quadratus. The pronator quadratus is then elevated in an L-shaped, ulnarly based flap. It is important not to elevate the ulnar aspect of the pronator quadratus as the distal radius blood supply comes from this area.

The deforming force of the radius stems from the brachioradialis. This tendinous structure must be released from its insertion on the radial styloid and extended proximally for 15 mm. It can be incised in a stair-step fashion to facilitate future tendon lengthening repair.

Pronate the proximal segment of the radius using a bone-holding clamp to debride callus using a freer and curette.

The fracture is reduced while supinating the proximal fragment and providing manual longitudinal traction.

Provisional K-wire fixation for maintaining reduction can be done.

Place the plate 2 mm proximal to the watershed line while maintaining the fracture reduction.

Provisional fixation is obtained with a bicortical nonlocking screw into the radial shaft (usually applied in a sliding slot, which enables the bone to be brought to the plate).

While maintaining the reduction, use k-wires through the proximal ulnar hole of the lunate head and proximal radial hole of the scaphoid head to secure the plate to the scaphoid and lunate fossa. Confirm the reduction fluoroscopically.

With appropriate reduction and plate fixation, bend the k-wires out of the way; drill (through the dorsal cortex), and fill the distal holes, starting with the distal medial peg of the lunate head (using a 16-mm screw), followed by the distal pegs of the scaphoid head, then the remaining pegs.

Drill (bicortical) and fill the remaining proximal shaft screws to complete the fixation.

Confirm reduction and screw length with an AP, lateral, oblique, and 10-degree lateral view. A dorsal horizon (sunrise) view can be used if screw penetration is a concern.

Repair soft tissues with closure of pronator quadratus in its place, then subcutaneous and skin sutures; use a soft postoperative dressing.

Postoperative check X-ray of the wrist were taken.

Patient were discharged after 5th P.O.D and were followed at intervals of two weeks, six weeks and twenty four weeks respectively

Both radiological and functional assessment were carried out. Standard postero-anterior and lateral views were taken to assess fracture pattern and to assess the parameters like palmar tilt, radial height, radial inclination, residual deformity. A radiological assessment was done with Sarmiento's modification of Lindstorm's criteria.

Functional status of the wrist was evaluated with DASH score.

Data was recorded in specially designed proforma and transferred to the master sheet.

Rehab after approximately 1 week postoperative

- Immediate finger motion

- Allow for light activities of daily living
- Splint as needed up to 4 additional weeks.

Statistical analysis

The statistical analysis will be done using MEDCALC statistical calculator. A P value < 0.05 was taken as statistically significant.

Plagiarism check was done using Drill-bit Anti plagiarism software. Pub-med is used for the review of articles.

Ethical considerations

Prior permission was taken from Institutional Ethics Committee, Andhra Medical College, Visakhapatnam

A written informed consent was taken from each individual of the study.

Observations and Results

Sixty patients were taken in this study. Thirty patients treated with closed reduction and casting and Thirty patients were treated with open reduction and plating. Among them thirty two were male and twenty eight were female. The mean age for males was 55.5 and 46.02 years in cast group and plating group respectively, and 45.5 and 44.6 years for females. The dominant side was affected in 46.6% of casting group and 50% in plating group. Metaphyseal comminution was present in 57.5% patients. The mechanism of injury by fall on out stretched hand was present in fifty patients. Ten patients sustained distal radius fracture in road traffic accidents. All except four patients were treated on the same day of injury; four patient of casting group were treated on next day of injury. In plating group, who were operated within first three days of injury, one patient developed pin site infection due to a k-wire which was used for provisional fixation. Infection resolved with antibiotics with out further sequelae. Four patients of same group developed superficial radial nerve paraesthesia.

Loss of follow-up in casting group was five patients and remaining twenty-five patients were followed up to six months. In open reduction and plating group loss of follow-up was five patients and rest of the patients were followed upto six months.

At follow-up patients were evaluated for pain, grip strength, range of movements, functional outcome, radiological outcome complications like infection, loss of reduction, finger stiffness, median nerve related complications, carpal tunnel syndrome etc. At the end of sixth week and twenty-four weeks pain over the affected side evaluated and categorized as nil, mild, moderate and severe according to patient's response. In our study, plating group have shown better outcomes in terms of pain relief when compared to casting group which is evident at six months follow-up. In our study, plating group have shown better outcomes in terms of grip strengths when compared to casting group which is evident at six months follow-up. In our study, casting group showed more stiffness than Plating group, both at 6 weeks and 6 months follow-up. The range of movements are better at 6 weeks and 6 months follow up in plating group when compared to the casting group.

Table 1: Functional status at 24 weeks

	Casting	Plating
Regular work	17 (68%)	19(76%)
Restricted work	7 (28%)	5(20%)
Unable to work	1 (4%)	1 (4%)
Total patients for follow-up	25	25

Table 2: Casting group radiological assessment

Average measurements	Pre-reduction (30 Patients)	Post-reduction (30 patients)	Six weeks (25 patients)	Six months (25 patients)
Radial Length (mm)	3.6	9.4	8.27	7.43
Volar Tilt (°)	-23.73	2.33	-3.42	-4.67
Radial Angulation (°)	9.16	19.23	18.56	16.21
Ulnar Variance (mm)	+2.3	+1.11	+1.46	+1.93

Table 3: Plating group radiological assessment

Average measurements	Pre-reduction (30 Patients)	Post-reduction (30 patients)	Six weeks (25 patients)	Six months (25 patients)
Radial length (mm)	4.56	11.03	10.2	9.8
Volar Tilt (°)	-23.46	+8.8	+6.9	+5.78
Radial Angulation (°)	11	19.66	18.02	17.44
Ulnar variance (mm)	-1.1	+0.43	+0.8	+1.02

Table 4: Casting group-radiological assessment

Parameters	Pre-operative (30 patients)	Post-operative (30 patients)	p-Value	Six Weeks (25 patients)	SIX Months (25 patients)	p-value
Radial			0.000*			0.489
Length	3.6	9.4	<0.05	8.27	7.43	
(mm)						
Volar			0.000*			0.404
Tilt (°)	-23.73	2.33	<0.050	-3.42	-4.67	
Radial			0.000*			0.181
Angulatio	9.16	19.23	<0.05	18.56	16.21	
N(°)						
Ulnar			0.002*			0.125
Variance	+2.3	+1.11	<0.05	+1.46	+1.93	
(mm)						

Table 5: Plating group-radiological assessment

Parameters	Pre-reduction (30 patients)	Post-reduction (30 patients)	p-Value	Six Weeks (25 patients)	Six Months (25 patients)	P-Value
Radial			0.000*			0.707
Length	4.56	11.03	<0.001	10.2	9.8	
(mm)						
Volar			0.000*			0.628
Tilt (°)	-23.46	+8.8	<0.001	+6.9	+5.78	
Radial			0.000*			0.250
Angulatio	11	19.66	<0.001	18.02	17.44	
N (°)						
Ulnar			0.101			0.210
Variance	-1.1	+0.43	>0.001	+0.8	+1.02	
(mm)						

Both the treatment methods showed significant outcome at the time of post-intervention. While comparing the radiological parameters at 6th week and 6th month, casting group have more significant changes in radiological parameters than the plating

group which indicates that plating helps in maintaining reduction better than casting.

Lindstrom and Frykman Grading

Table 6: Anatomical outcome (AT 6th month)

	Casting		Plating	
	Number of Patients	Percentage	Number of Patients	Percentage
GRADE I	8	32%	10	40%
GRADE II	15	60%	14	56%
GRADE III	2	8%	1	4%
GRADE IV	0	----	0	-----

Anatomical assessment was done according to Lindstrom and Frykman criteria. In Cast group eight patients had grade I i.e. no deformity as compared to ten patients in plating group. In casting group majority patients i.e. fifteen had grade II

outcome i.e. mild deformity. In plating group grade II (mild deformity) and grade III (moderate deformity) outcome was observed in fourteen and one patient respectively. Grade IV outcome i.e. severe deformity was absent in both groups.

Disability of arm, shoulder and hand (dash) scoring**Table 6:** Functional assessment

Mean dash score at end of	Casting (SD)N=25	Plating (SD)N=25	p-Value
6 Weeks	9.36	9.81	0.33
6 Months	10.47	4.73	0.0048

The functional outcome was evaluated at end of six weeks and six months with Disability of Arm Shoulder and Hand (DASH) scoring. This system consists of thirty set of questionnaire for subjective evaluation including activities of daily living.

By this system average scores were calculated and were 32.93 for plating group at six weeks as compared to 35.56 for cast immobilization group. At end of six months scores were 15.72 and 22.52 respectively for plating and casting groups.

Mean DASH scores were compared in two groups at the end of six weeks and six months. At end of six weeks p-value was 0.33 (>0.05) and at end of six months p-value was 0.0048 (<0.05) indicating significant difference between two groups in terms of functional outcome at six months follow-up but not at six weeks follow-up.

Discussion

The treatment of distal radius fractures is an area of constant debate. The lack of correlation between anatomical (radiological) outcomes and functional outcomes has further added to this.

The above depicted treatment algorithm outline the management of the distal end of the radius based on displacement and presence of high energy trauma which will decide the further type of treatment to be employed. Usually, minimally displaced fractures and low velocity injuries will do fine with cast immobilization, provided the reduction is

maintained throughout the follow-up and a subsequent vigorous physiotherapy protocol.

There is a general acceptance among treating surgeons that patients with lower functional demands such as elderly females (which constitutes the most Common age group for these fractures encountered in OPDs and ERs) do well even in the presence of deformity, which results either from the fracture untreated or even after the treatment. So, this has favored many to opt for conservative management.

The improvement in knowledge and understanding of the functional anatomy of hand and wrists has warranted an improved precision in addressing these fractures.

In our study, We have chosen A2, A3 & C1 fractures and above 18 years aged patients. Most of the studies which compared those two techniques were either done on elderly people or included only extra-articular fractures. So, our study is superior in the aspect that it includes a wider age spectrum in which the treatment techniques have been studied. We also compared simple intra-articular fractures as well.

Functional outcome by Disability of Arm, Shoulder and Hand (DASH) score, though lower score indicates better function, the plating group had lesser mean scores compared to the casting group both at six weeks and at six months but statistically significant at 6 months follow-up, which suggests that there is significant difference between the two groups in terms of functional outcome which comes to be better in plating group.

Table 7: Comparing DASH-scores to other studies:

	Casting	Plating	Mean Difference
Our Study	22.52	15.72	6.8
Arora 2009	11.6	11.1	0.5
Arora 2011	8	5.7	2.3
Bartl	19	14	5
Chan	6.2	6.7	-0.5
Egol	12.1	10	2.1
Saving	23.1	15.6	7.5
Zengin	17.6	11.7	5.9

While comparing DASH scores to other studies, most of these studies including our study concluded that the plating provides better functional outcome than casting (except for Chan et. Al, which concluded that Casting providing better

functional outcome than Plating). Only difference between our study and others was that our follow-up is short term (6 months follow-up) compared to medium and long term follow-up (> 1 year in other studies)

Table 8: Comparing radiological outcome to other studies

Parameter	Zengin et. al		Our study	
	Casting	Plating	Casting	Plating
Radial inclination	16.6	21.5	16.21	17.44
Radial height	7.8	10.4	7.43	9.8
Volar tilt	-1	6.9	-4.67	5.78
Ulnar variance	2.1	1.7	1.93	1.02

While comparing radiographic parameters to Zengin *et al.*, all parameters were better restored and maintained in Plating group than Casting group in our study, similar to Zengin *et al.* In three patients who underwent volar plating showed high or poor DASH scores which attributes to mal-reduction, bad

fracture geometry and poor compliance of the patient to the physiotherapy as can be seen with the patient shown in case illustration-2 in plating group. Plating groups showed statistically good functional outcome scores compared to the casting group at 6 months follow-up.

At sixth month post-intervention seventeen patients (68%) of casting group continued their daily activities in contrast to nineteen (76%) patients who underwent plating.

After the intervention, both groups of patients had significant improvements in radiographic criteria such as radial height, volar tilt, radial inclination, and ulnar variance (all with p values 0.005). In both of these groups, there were no significant changes in all of these parameters between the sixth week and the sixth month after intervention, but changes in the plating group were lower than in the casting group, indicating that the plating is better at maintaining reduction.

In both groups, finger stiffness was a major issue. At six weeks, ten patients (40%) in the plating group showed finger stiffness, relative to twelve patients (48%) in the casting group.

Six patients of plating group developed tendinopathy of flexor tendons that resolved with physiotherapy on follow-up at sixth week in five patients but not resolved in one patient.

Ten patients of plating group had finger stiffness at six week follow-up that gradually resolved by six months in 6 patients and at end six months only four patients had finger stiffness of mild degree. Four patients had shoulder stiffness unrelated to operative procedure that gradually resolved by nine weeks with shoulder mobilization exercises. No patient of this group developed median nerve neuropathy or other complications viz; compartment syndrome, carpal tunnel syndrome.

In closed reduction and casting group major complications were finger stiffness in twelve patients at 6 weeks. At end of six months finger stiffness resolved in four patients and rest of the eight patients had finger stiffness of mild to moderate degree at end of the six months. Similar to plating group four patients of closed reduction and casting group had shoulder stiffness that resolved by nine to ten weeks with shoulder mobilization and physiotherapy.

Table 9: No. of patients with complications in both groups at 6 months

Complications	Casting	Plating
Stiffness	8	4
Tendinopathy	0	1
Complex regional pain syndrome	1	0
Residual pain	8	5
Post traumatic arthritis	2	0
Shoulder stiffness	0	0
Mal-union	6	3
Non-union	0	0
Infection	0	1
Medial nerve neuropathy	0	0
Carpal tunnel syndrome	0	0
Compartment syndrome	0	0

In terms of return to daily activities, plating group showed better results when compared to the casting group as evident in the above bar diagram showing return of function in two groups. Restricted work was seen more in casting group than plating group.

According to the DASH score, plating yielded statistically better functional outcomes. In both groups of patients, changes in radiological parameters were non-significant between the sixth week and the sixth month after intervention. Normal anatomy must be restored in order to regain the function. Normally, the distal radius bears 82 percent of the compressive force at the wrist joint, while the distal ulna bears the rest. With a 2.5 mm decrease in radial height, the ulna bears 42% of the strain, and with a 20 degree dorsal

angulation, the ulna bears 50% of the strain.

Anatomical assessment suggested that Plating is more efficient in restoring anatomical parameters than casting. Both casting and plating not showed severe deformity (grade IV) in any of the patient in their respective groups.

The most critical component in preserving function is restoring radial height. Depending on the volar or dorsal displacement of the ulnar head inside the sigmoid notch, radial height loss might result in ulnar impaction or DRUJ dysfunction, with reduced range of motion in supination and pronation.

The most clinically important radiographic measure in terms of both functional result and potential degenerative alterations is radio-carpal articular congruity. On x-rays, there was a 100% chance of degenerative changes if there was 2 mm of incongruity. Residual dorsal tilt can cause ulnar impaction, mid-carpal instability, and a shift in stress distribution, all of which can progress to early degeneration.

According to Gartland and Werley, residual dorsal tilt has a greater impact on outcome than residual radial deviation, radial shortening, or loss of radio ulnar joint integrity.

Porter believed that loss of function did not begin until at least 20 degrees of palmar tilt had been lost in his study.

Radial height, ulnar variance, and radial inclination are restored to near-normal levels in both treatment techniques, although dorsal tilt is not completely corrected. This is attributable to the fact because volar ligaments are harder on distraction than dorsal ligaments that are more 'Z' orientated. As a result, when distracted, the volar cortex extends ahead of the dorsal cortex, limiting full correction of dorsal tilt.

Cast immobilization alone was not enough to keep unstable fractures from losing reduction, resulting in unsatisfactory anatomical outcomes. At the end of six months, functional outcomes in the studied types showed better DASH scores in plating group than casting group (p value-0.0048).

Conclusion

Casting and Plating, both techniques yield good radiological and functional outcome in unstable distal end of the radius fractures in short term follow-up of 6 months with anatomical or radiological parameters restoration and maintenance, more evident in plating group.

Through our study, we conclude that the both treatments give good results when considering functional outcomes. But the use of volar plating, gives better patient reported functional outcome (though statistically insignificant at six weeks, but significant at six months follow-up) and provides early range of motion and aids in rapid recovery of function. The range of motion in terms of casting group, improved with vigorous physiotherapy after a duration of 4- 6 weeks in our study.

Our study also suggest that plating is a better option in non-elderly patients, in view of better functional outcome and lesser complications when compared to the elderly patients.

Finally our study indicating that the plating is the best option for patients who are technically demanding and who wants an accelerated recovery of function while the casting is the best option for patients whose working capacities are sub-optimal and who is not in favor of any reoperation.

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