A novel technique of ulna strut grafting for post-septic radial clubhand deformity: Case series of 4 patients with review of literature

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ABSTRACT

Background: Though distal end radius fractures are one of the commonest fractures to occur, their nonunions are extremely uncommon. Out of these, post-septic defect nonunions with acquired radial clubhand deformity are even more rare and pose unique problems in management. We present a case series of 4 patients of post-septic radius nonunion with acquired radial clubhand deformity successfully treated with a novel technique of using Ulna Strut grafting for radius defect after ulnar shortening. All 4 patients have a good functional and cosmetic outcomes with radiological union at the cost of minimal limb length discrepancy of the forearm.

Methods: This is a case series of 4 patients with a retrospective study design and study duration of 3 years from August 2016 till March 2019. 4 patients presenting to us with post-septic defect nonunions of radius with an acquired radial clubhand deformity were selected with a mean age of 19.75 years which included 2 males and 2 females.

Results: The mean time for radiological union was 3.125 months. The average range of motion at the wrist joint was 35° of flexion and 50° of extension with average pronation being 47.5° and supination being 75°. There were no subsequent complications reported in these patients except for a minimal limb length discrepancy with satisfactory functional outcomes in all the patients.

Conclusion: The use of Ulnar shortening and Ulna strut grafting for the treatment of defect nonunions of radius with acquired clubhand deformity yielded predictable results. It is a simple procedure that does not require additional training, with no additional morbidity of iliac crest or fibula bone grafting and had a minimum complication rate. The technique looks promising in the future, though a study on a larger population would further strengthen the predictability of this unique technique.

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1. Introduction

1.1. Background

Nonunions of distal end radius are extremely uncommon, accounting for approximately 0.2% of all cases.¹ Post-septic defect nonunion of Radius with an acquired Radial Clubhand deformity after a distal forearm fracture is a very unique, yet a challenging reconstructive problem.

A lot of issues need to be addressed in these patients with

infection being on the priority list followed by nonunion, bone loss, distal radio-ulnar joint incongruity and loss of functional wrist and hand stability. Various treatment modalities have been described in the literature which include debridement followed by cancellous bone grafting and/or non-vascularised or vascularised fibula grafting and iliac crest strut grafting (Nicolle's technique), open reduction and internal fixation of radius with ulnar shortening, bone transport using an external fixation and creation of a single bone forearm.

1.2. Rationale

Although vascularised or non-vascularised fibula grafting has been well described for the management of both upper limb and

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Table A

Patient information.

Pt. No	Age/ Sex	Mechanism of injury	Previous treatments	At Presentation	Management
1	12/F	Fall on outstretched hand	K wire fixation in 2015, removal done after one month due to pin track infection	Right sided Pathological fracture secondary to osteomyelitis	2 Stages (Gap of 4 weeks) Stage 1: Debridement and cement spacer with Ex-Fix Stage 2: Ulna shortening and Plating (Ulna Strut as bone graft) (Intraop Radial defect – 4 cm)
2	11/M	Fall on outstretched hand	K wire fixation in 2017, removal done after 3 weeks due to pin track infection	Left sided Pathological fracture secondary to osteomyelitis	2 Stages (Gap of 6 weeks) Stage 1: Debridement and cement spacer with Ex-Fix Stage 2: Ulna shortening and Plating (Ulna Strut as Bone graft) (Intraop Radial defect – 2 cm)
3	29/M	Road traffic accident with both bone forearm fracture	Plating in 2016 Plate removed 3 months later due to infection	Right sided Defect nonunion of distal third radial shaft	2 Stages (Gap of 6 weeks) Stage 1: Debridement and Cement Spacer with Plating Stage 2: Ulna Shortening and Bone grafting with Ulna strut (Intraop Radial defect – 3.5 cm)
4	17/F	Road traffic accident with both bone forearm fracture	TENS Nailing in 2016, nails removed 6 months later	Left sided Defect nonunion of distal third radial shaft	Single Stage Debridement with Ulna Shortening and Plating (Ulna strut graft as Bone graft) (Intraop Radial defect – 3 cm)

lower limb nonunions, no similar report exists in the literature regarding the use of ulna strut grafting in patients with gap

nonunion of radius with acquired radial clubhand deformity.

In this article, we have presented a novel technique of ulna strut

Fig. 1. Treatment strategy in a 29 yr/M with distal radial shaft nonunion. 1a. X-ray of 29 year/M with defect nonunion of distal end radius and Distal radio-ulnar joint disruption. 1b. Clinical pics of radial clubhand deformity showing dorsal ulnar subluxation. 1c. First stage with insertion of antibiotic cement spacer in the defect and stabilisation with plating. 1d. Postop Xray after first stage. 1e. Second stage with removal of cement spacer. 1f. Harvesting ulna strut graft and ulnar shortening with correction of ulnar variance using standard approach. 1g. Postop Xray at 1 year followup showing complete radiological union and ulna graft incorporation. 1h. Clinical pics showing good functional and cosmetic outcomes at the end of 1 year.

Fig. 2. Treatment strategy in a 11 year old boy with distal end radius nonunion. 2a. X-ray showing gap nonunion with gross distal radio-ulnar joint disruption. 2b. Clinical pics with radial clubhand deformity with on and off discharging sinus. 2c. First stage showing the defect site with ivory white sequestrum. 2d. Removed sequestrum. 2e. Postop Xray after first stage of debridement and cement spacer and stabilisation with external fixator. 2f. Second stage intraoperative pic showing induced membrane formation. 2g. Harvesting ulna strut graft and ulnar shortening with correction of ulnar variance using standard approach. 2h. Postop Xray at 1 year followup showing complete radiological union and ulna graft incorporation. 2i. Clinical pic showing completely healed scar and good cosmetic outcome at the end of 1 year.

grafting in 4 patients with gap nonunion of radius with acquired radial clubhand deformity. The details of the technique of the two-staged approach has been described below.

2. Methods

This is a case series of 4 patients with a retrospective study design and study duration of 3 years from August 2016 till March 2019. 4 patients presenting to us with post-septic defect nonunions of radius with an acquired radial clubhand deformity were selected for the study with a mean age of 19.75 years which included 2 males and 2 females. Of these 4 patients, 2 patients had nonunion at the site of distal end radius and the other 2 patients had radial shaft nonunions. Details of all the patients with relevant history and their previous treatments are given in Table 'A'. All patients were followed up at regular intervals at 1 month, 3 months, 6 months and one year after the definitive fixation.

2.1. Treatment strategy

3 out of 4 patients had presented to us with radius gap nonunion with a serous discharging sinus on and off secondary to post-operative fixation for a distal end radius or a shaft radius fracture (Figs. 1a,b,2a,b,3a,4a). Clinically, these 3 patients were afebrile with a mildly raised blood infection markers like ESR and CRP. One patient had no evidence of discharging sinus and had normal

infection markers.

A two staged approach had been performed except in one case where the patient was treated in a single stage in which the blood infection parameters were normal with no discharging sinus.

In the first stage, radical debridement with sequestrectomy was performed. It included thorough debridement of the wound with sinus excision and removal of the loose sequestrum (Fig. 2c,2d,4b,4c). Both proximal and distal fragments were debrided of remnants of granulation tissue and excess fibrosis. The necrotic and sclerotic fragment of the radius on either sides were cleared till fresh bleeding of bone edges was seen. The medullary cavity of the bone fragments were opened to produce fresh bleeding. The fascia over the muscles and soft tissue were debrided to stimulate vascularity. Finally the defect created was bridged using an antibiotic cement spacer which included Vancomycin and Tobramycin (Fig. 1c,4d). Stabilisation of the bone was done using either an external (Fig. 2e,4e) or an internal fixation device (Fig. 1d,2c) depending on the size of the distal fragment and the bone quality. In 2 patients with shaft nonunion, plating was done as the size of distal fragment was considerably large. In the other 2 patients in whom the fragment was small, wrist spanning external fixator was applied. However, the pins were placed far away from the infective nonunion site with distal pins in the metacarpals and proximal pins in the radial shaft. This was done to keep the vulnerable distal fragment virgin preserving its biology as much as possible for future surgery and avoiding the stressful

effects of plating over an already compromised bone.

After the first surgery, suture removal was done after 2 weeks and finger range of motions encouraged during this period. Post operative i.v and oral antibiotics were given for a period of 6 weeks as per the culture and sensitivity reports. The second stage was performed after an average period of 4–6 weeks after the infection looked quiescent with no discharge from the wound and decreasing ESR and CRP trends.

Second stage was the definitive procedure which included removal of the cement spacer (Figs. 1e and 2f), osteotomy of the distal ulna and correction of the ulnar variance and removing the excess length of ulna strut after correction of the variance. Distal ulna was exposed by its classical approach and level of ulnar osteotomy was marked over distal ulna (Figs. 1f and 2g) such that at least 2 or 3 screws of plate accommodate in the distal fragment. The radio-ulnar variance was then corrected. That length of proximal ulna which was found overlapping with the distal fragment after the correction of variance was then cut and used as a strut graft to bridge the radial defect. Both radius and ulna were subsequently stabilised using internal fixation with plating (Figs. 1g and 2h,3c,4f).

2.2. Post-operative care

The patients were immobilised in an above elbow slab for about 2 weeks till suture removal and range of motion exercises were started for hand, wrist and forearm.

The patients were followed up at regular intervals at one month, 3 months, 6 months and one year with good functional and cosmetic outcomes reported at the end of one year (Fig. 1g,h and 2h,2i,3d,4g).

3. Results

The mean time for radiological union was 3.125 months. The average range of motion at the wrist joint was 35° of flexion and 50° of extension with average pronation being 47.5° and supination being 75°.

Wrist range of motion and pronation and supination movements were more restricted in the 2 patients with distal end radius nonunions as compared with the other 2 patients with radial shaft nonunion who had better functional outcomes. The probable explanation for gaining more supination than pronation may be because of the postoperative immobilisation of forearm in full supination. All patients had insignificant limb length discrepancy due to ulnar shortening with 2 patients having a discrepancy of 2 cm and the other 2 patients with a 1 cm discrepancy. Individual functional outcomes have been tabulated in the Table 'B'.

4. Discussion

Post-septic defect nonunion of radius with acquired radial clubhand deformity is an exceptionally rare entity and a challenging condition. Multiple problems have to be dealt with which include infection, poor soft tissue condition, fibrosis of bony ends and damage to the periosteum contributing to a poor healing potential. Although vascularised or non-vascularised fibula grafting has been well described for management of both upper limb and lower limb nonunions, no similar report exists in the literature regarding the use of ulna strut grafting which is a simple and easily reproducible technique with a minimum complication rate and shorter duration of treatment.

A lot of treatment modalities have been used for the management of this unique problem with pros and cons of each one of them. Netrawichien² reported good results in 2 paediatric cases of

radial clubhand in which a 2-staged approach was used. First stage included iliac crest bone grating for the radial defect and second stage included correction of radio-ulnar subluxation with ulnar shortening similar to the principle used in our case series of 4 patients.

Centralisation of ulna has been widely accepted as a treatment of choice of radial clubhand, described by Riordan in 1955. But this technique might not be suitable in the cases we reported because in all these cases, the distal part of the radius, including the distal physis still remained. Malki et al.³ described centralisation of ulna using modified Hay-Groves procedure which differs from the original procedure in that it preserves the distal end of the ulna with its important triangular fibrocartilage complex, thereby retaining stability and contour of the wrist joint. The patient had cosmetically acceptable one-bone forearm with stable wrist, good grip but a significant compromise in the form of no forearm rotations. Also, one bone forearm can serve as a useful salvage procedure in cases of extensive bone loss and distal radio-ulnar joint complications.

Dr.D.D Tanna⁴ published a case series of 6 cases in which the radial defect was treated with iliac crest bone grafting and distal radio-ulnar joint was managed using either Sauve-Kapandji procedure or Darrach's procedure but the mean age of the study was 47.8 years.

Our study was done in a relatively younger population in which these procedures may not be valid.

Strut grafting techniques have also been used for the management of radial shaft nonunions by most of the authors. Venkateswarlu⁵ reported a case which was successfully treated using modified Nicolle's method where intramedullary nailing and iliac crest strut grafting was used instead of plating which was originally

Fig. 3. Single Stage treatment strategy in a 17 year old female with distal end radius nonunion with no signs of infection and normal blood parameters. 3a. X-ray showing defect nonunion of shaft radius with acquired radial clubhand deformity. 3b. Immediate postoperative X-ray showing correction of ulnar variance and use of ulna strut graft as a single stage procedure. 3c. Postoperative X-ray at one year followup showing complete radiological union and restoration of normal wrist parameters. 3d. Clinical pics showing good functional outcomes at one year followup.

Fig. 4. Treatment strategy in a 12 year old female with distal end radius nonunion. 4a. Xray showing pathological fracture with features of chronic osteomyelitis. 4b. Intraoperative pic showing ivory white sequestrum with no evidence of bleeding on drilling. 4c. 5 cm long sequester. 4d. Insertion of cement spacer in the defect. 4e. Postoperative Xray after debridement and cement spacer and stabilisation of external fixator. 4f. Postoperative Xray one year after the second stage showing complete radiological union. 4g. Clinical pic showing functional outcomes at the end of one year.

Table B

Results with postoperative Functional outcomes.

Pt no.	Wrist flexion (Before/After)	Wrist extension (Before/After)	Pronation (Before/After)	Supination (Before/After)	Limb length discrepancy	Time for Union	Followup
1	10/20	10/40	20/30	0/80	2 cm	4 months	4 years
2	20/40	20/40	20/30	0/80	1 cm	2.5 months	1 year
3	20/40	40/60	30/70	0/70	2 cm	3 months	1.5 years
4	20/40	50/60	30/60	0/70	1 cm	3 months	1 year

described by Nicolle. Dr.Sandeep Patwardhan⁶ published a series of 26 patients of long bone defect nonunion successfully treated using nonvascular fibula strut grafting with limb length discrepancies and delayed nonunions in a few. These techniques of strut grafting, though successful, had an extra donor site morbidity associated with them. Although in both these papers, the patients were found to have a congruent distal radio-ulnar joint. But in patients with radial shaft nonunion and accompanying acquired radial clubhand deformity, our method of Ulna shortening and using it as a strut graft for radial defect simultaneously treats both these problems.

The principle of distraction osteogenesis has also been reported by many authors for the management of acquired radial clubhand deformity with large defects.

Zhang X⁷ had successfully treated 13 patients treated by callus distraction using a two-segment monolateral external fixator. Similarly, other authors like Sabharwal et al.,⁸ Hosney,⁹ Pickword et al.¹⁰ and Sakurakichi K¹¹ reported fair results using Ilizarov

technique. However, the technique of Ilizarov has its own list of complications like pin tract infections, delayed union, longer duration of treatment, loosening of pins, need for revision surgeries and additional bone grafting, patient compliance and the technique itself which is complex and needs expertise and may not be reproducible by all trauma surgeons.

In this series, we have successfully treated 4 cases in a staged approach with thorough debridement and cement spacer insertion in first stage followed by spacer removal and ulna strut grafting supplemented by internal fixation device in the second stage. We reported fair functional outcomes in all patients with a mean age of union of around 3 months. Limb length discrepancy was found to be 2 cm in 2 patients which was not clinically significant. Slight limitation of wrist activity was found in 2 patients who had a distal end radius defect which was very near to the wrist joint but they were able to do their daily routine activities.

Our series has the inbuilt shortcomings of a retrospective study.

However, the event of radius nonunion with acquired radial club-hand deformity is so rare that it is very difficult to plan a large size prospective study which includes various treatment modalities. Difference in patient profile and available implants confound the surgical choice, however the principles of surgery remain the same and thus provide valuable inferences.

In conclusion, the use of Ulnar shortening and Ulna strut grafting for the treatment of defect nonunions of radius with acquired radial clubhand deformity yielded predictable results. It is a simple procedure that does not require additional training, with no additional morbidity of iliac crest or fibula bone grafting and had a minimum complication rate. This technique is not be suitable for bone defects more than 4 cm due to unacceptable level of forearm shortening. Also, we did not take into account the slope of distal radio-ulnar joint while considering the use of this technique. So long term follow-ups would be needed to assess the final outcomes of distal radio-ulnar joint. Although its difficult to do a prospective study on a larger population, this novel technique will carry a very significant impact if done so.

Ethical considerations

Parental consent for using this technique and for use of imaging for the case report was done according to Trust protocols.

References

1. Peter Kloen, Geert A. Buijze, David Ring. Management of forearm nonunion: current concepts. *Strat Traum Limb Recon*. 2012;7:1–11.
2. Netrawichien P. Radial clubhand like deformity resulting from osteomyelitis of the distal radius. *J Paediatr Orthop*. 1995;15:157–160.
3. Malki A, Wong-Chung J, Hariharan V. Centralization of ulna for infected nonunion of radius with extensive bone loss: a modified Hey-Groves procedure. *Injury*. 2000;31:345–349.
4. Tanna Dilip D, Shyam Ashok K. Nonunion distal radius fracture – case series of 6 cases with Review of Literature. *Trauma International*. 2015 July-Sep;1(1): 31–35.
5. Venkateswarlu BS, Manikumar CJ. Infected gap non union of radius treated with modified nicoll's technique-A case report. *J Clin Diagn Res*. 2015 Feb;9(2): RD01–RD2.
6. Patwardhan Sandeep, Shyam Ashok K, Adi Mody Rustom. Reconstruction of bone defects after osteomyelitis with nonvascularized fibular graft. *J Bone Joint Surg Am*. 2013;95(1-6):e56.
7. Zhang X, Daun L, Li Z, et al. Callus distraction for the treatment of acquired radial club hand deformity after osteomyelitis. *J Bone Joint Surg*. 2007;89B: 1515–1518.
8. Sabharwal S. Treatment of traumatic radial clubhand deformity with bone loss using Ilizarov apparatus. *Clin Orthop*. 2004;424:143–148.
9. Hosney GA. Forearm lengthening. *J Orthop Traumatol* 2005; 6: 132–137.
10. Pickford MA, Scheker LR. Distraction lengthening of the ulna in radial club hand using Ilizarov technique. *J Hand Surg*. 1998;23:186–191.
11. Sakurakichi K, Tsuchiya H, Kabataa T, et al. Correction of juxtaarticular deformity in children using the Ilizarov apparatus. *J Orthop Sci*. 2005;10:360–365.