

MANAGEMENT OF INFECTED PAEDIATRIC NON-UNION BOTH BONE FOREARM WITH DISTRACTION BY RING FIXATOR FOLLOWED BY FREE FIBULAR GRAFTING: A CASE SERIES

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Received : 09/05/2023
Received in revised form : 02/06/2023
Accepted : 13/06/2023

Keywords:

Endotracheal tube, Alkalinized lidocaine, Cuff-related complications.

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DOI: 10.47009/jamp.2023.5.3.402

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (3); 2041-2046

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Abstract

Background: Infected non unions of both bone forearm are challenging cases, particularly of pediatric population with scant literature existing regarding proper management. Different methods like Masquelet technique, distraction histogenesis, two stage procedure with linear external fixator followed by bone grafting, fibular allograft, match box grafting and vascularised fibular grafting have been tried each with its own share of success and failures. In our study infected non unions were treated with two stage procedure: control of infection with debridement & distraction by Illizarov ring fixation, followed by fibular grafting. **Materials and Methods:** Nine cases with infected non union of both bone forearm below 16 years of age were managed by the two stage procedure. In the first stage radical debridement was undertaken with excision of sinus tracts and sequestrectomy followed by Illizarov ring fixator with two ring constructs was done. In second stage, after 4-7 weeks with ring fixator in situ, the non union site was spanned using autologous fibula. Fixation was done at either ends with minimal hardware: stainless steel wire or mini-fragment titanium screws. Follow-up was continued till union both radiologically and clinically. Physiotherapy and active and passive movement and stretching was done. **Result:** Time of presentation since injury ranges from 1 year to 11 years, mean duration being 4yrs. Non union gap ranged from 2 cm to 11.5 cm, averaged defect being 7 cm. Time in fixator ranged from 3 months to 6 months with average duration of 4 months. All cases achieved union with average time to union being 19 weeks. Outcome assessment using the ASAMI Scale yielded three excellent and five good results out of nine cases. **Conclusion:** : Two stage procedure with stage 1 distraction by Illizarov ring followed by fibular grafting in stage 2 is not only a good economical approach but also one of the best systematic approaches, which not only achieves union, control of infection but also addresses associated problems like deformity, contracture, developmental & disuse atrophy, osteoporosis and promotes early function and mobilisation.



INTRODUCTION

Non-union of both bone forearm in paediatric patients which was once reported rarely is increasing nowadays.^[1,2] Non-union fracture of

radius or ulna is much more rare,^[3,4] therefore scant literature is available - mostly case reports. Different methods have been applied so far – Masquelet technique,^[5] distraction histogenesis, two stage procedure with linear external fixator followed by

bone grafting,^[6] fibular allograft,^[7] match box grafting, vascularised fibular grafting, even single bone reconstruction and fibular allograft.^[2] Each method has its success but no systematic approach to deal with such a complex problem has evolved till now.

Infected non-union radius has multiple other issues- infection, shortening, distal radio-ulnar joint dislocation/ subluxation, soft tissue contracture (giving rise to deformities like varus valgus malalignment, stiffness of wrist joint movement, restriction of pronation-supination and osteoporosis. So achieving union should be primary goal which has to be preceded by eradication of infection first. But DRUJ issue needs to be addressed with correction of valgus varus deformity along with contractures which can be done by distraction histogenesis. Such logical thinking led to hypotheses – management of infected non-union radius may be best treated with two stage procedure: control of infection with debridement & distraction by Illizarov ring fixation, followed by fibular grafting.

Aims & objectives

Purpose of the study was to achieve union with best possible anatomical position to get best functional outcome.

- To control infection
- To distract radius to gain length-alignment, correct deformity- contracture, DRUJ alignment
- To achieve union (by grafting)
- To get best possible function

MATERIALS AND METHODS

The study is retrospective study and is a case series.

Inclusion Criteria

- Paediatric patients up to 16 years of age with infected non-union radius and ulna.
- Cases treated with debridement with Illizarov ring fixator, followed by fibular grafting.

Exclusion Criteria

- Adult patients
- Treatment otherwise- e.g. single bone reconstruction/ distraction only.

After informed consent, procedure was undertaken with proper pre-operative investigations including pre-op X-rays, routine tests. In stage one, thorough radical debridement was undertaken with excision

of sinus tracts, sequestrectomy, curettage, opening medullary canal by anterior approach. Samples for biopsy and culture sensitivity were sent. Illizarov ring fixator was applied with two ring constructs. Distraction was started after 5 days, and continued at the rate of 1mm/day, till distal radio-ulnar joint anatomical alignment was achieved. Correction of contractures by distraction was done as much as possible and associated deformities were also corrected as needed.

In second stage, after 4-7 weeks with ring fixator in situ, the gap of non-union site opened through anterior approach. Fibula of appropriate length was harvested which was slightly larger so that bevelled ends with step cut overlaps on either side at least 1 cm. Multiple holes were made in different planes with sharp k-wires or drill bits. Fixation was done at ends with minimal hardware: stainless steel wire or mini-frag titanium screws, except in one case where plate fixation was done. Illizarov ring fixator was kept as primary stabiliser and replaced with POP cast after 6-8weeks. Follow-up continued till union radiologically and clinically. Physiotherapy and active and passive movement and stretching was done.

Documentation of clinical & radiological findings was done.

RESULTS

Nine cases were studied with age ranging from 7 yrs to 14 years, mean age being 9years. Male were 5, female was 4. Number of previous surgeries ranged from 2 to 7 times with average number of previous surgeries being 4 times. Time of presentation since injury ranges from 1year to 11 years, mean duration being 4yrs. Defect ranged from 2 cm to 11.5 cm, averaged defect being 7 cm.

Union was achieved in all cases.

Time in fixator ranged from 3 months to 6 months with average duration of 4months. Time to union ranged from 16 weeks to 28 weeks with average time to union being 19 weeks.

Outcome: ASAMI scoring was used for grading results of bony union:

- Excellent- 3
- Good-5
- Fair- 1
- Poor -0

Table 1: Master Chart

	Age	sex	Duration of non-union	No of procedures undertaken	Procedures undertaken	Duration in ring fixator in stage I +II	Pop after removal of fixator	Time of union	Results
1	11yrs	f	6yrs	5	Fibular grafting +mini-frag screw	14wks+16wks	12wks	42wks	good
2	15yrs	m	3yrs	3	Fibular grafting + cerclage wiring	6wks+12wks	6wks	24wks	good
3	17yrs	m	4yrs	6	Bi-cortical iliac graft+ screw	9wks+14wks	8wks	32wks	Fair
4	8yrs	m	2yrs	3	Fibula+ss wire	8wks+12wks	7wks	27 wks	Good
5	8 yrs	m	28 months	3	Fibula+plate	8wks+3wks	0	16 wks	Excellent
6	9yrs	m	38 mths	4	Fibula+ss wire	9wks+11wks	9 wks	29wks	Good

7	8yrs	m	26wks	2	fibula	7wks + 7wks	8wks	22wks	Excellent
8	15yrs	f	18wks	2	fibula	4wks+8wks	6wks	18wks	Excellent
9	10yrs	m	26wks	3	Fibula +k-wire	12 wks+8wks	6wks	26wks	Good

Case 1:

Pre-Operative



Intra Operative



6 Month Followup



Early Post Operative



ASAMI Scoring of results of bony union(17):

Excellent	Union, no infection, deformity < 7°, limb-length discrepancy < 2.5 cm
Good	Union + any two of the following: absence of infection, < 7° deformity and limb-length inequality of < 2.5 cm
Fair	Union + only one of the following: absence of infection, deformity < 7° and limb-length inequality < 2.5 cm
Poor	Nonunion/re-fracture/union + infection + deformity > 7° + limb-length inequality > 2.5 cm

DISCUSSION

Non-union of both bone forearm fractures in children is rare. Most non-union series reported, reveal non-union of ulna. Isolated case reports of non-union radius are found which are treated with individual varieties of techniques, with no series following any definitive systematic approach to deal with defect non-union after fracture fixation failed in paediatric age group.

In this case series, union was achieved in all cases, infection was controlled in all cases. DRUJ was paid attention from very beginning and reasonable alignment and function was regained. No attempt for reconstruction of DRUJ was also adopted. Varus and valgus were corrected and contracture addressed. Significant tissue regeneration was evident. Angiogenesis helped in earlier graft incorporation and control of infection.

Fernendase Et al,^[10,11] reported only 6 cases of non-union of ulna in a retrospective series of 537 case. Only 6 cases were found with pseudo-arthritis of ulna after ESIN. There were no gap and were mostly asymptomatic.

Rami Khalifa et al reported 8 cases of non-union in a retrospective study with 12 cases; mostly tibia was involved and 50% cases after osteotomy.^[12-15]

Agarwal et al,^[5] described non-union in paediatric patients which was managed with non-vascularised fibula but after infection of mostly lower limb.

John Mukherji et al,^[4] described two cases of defect non-union of radius, which was managed by two stage procedure with Masquet technique. Good outcome was achieved in spite of long gap.

Dimatrino S et al,^[17] in a review of non-union of forearm in adults & children, proposed an algorithm for paediatric non-union. Only one case was exemplified –non-union found with conservative management with pseudo arthritis but no gap or defect.

Loose et al,^[13] described in a case series of paediatric non-union of both bone forearm, where out of 27 cases, non-union of ulna was found in 21 cases and recommended conservative approach mostly with operative procedure in symptomatic cases.

Treatment of non-union both bone forearm with Illizarov ring fixator is reported for adult patients.^[16] This is the single largest series with defect non-union radius in paediatric age group. And all cases were managed with Illizarov ring distraction followed by free fibular grafting with acceptable outcome. Fixed protocol of distraction by Illizarov ring fixator, followed by 2nd stage fibular grafting with minimum hardware was used in all cases. Reasonable outcome was achieved with union in all cases and showed 90% cases as good to excellent result as per ASAMI criteria.

Non-union radius in children was very rare earlier, as conservative measures usually resulted in union

with tremendous potential of regeneration in children. Most of studies deal with non-union of radius and ulna in adults.^[8,9,17,18] With increasing operative interference and high energy trauma, cases of infected non-union is now not infrequent nowadays.^[11-13] Paediatric non-union case series are sparse in literature,^[10,11] found ulna to be involved in most cases. For radial defect non-union mostly case reports are found.^[4,5,9] John Mukhopadhyay et al reported 2 such cases dealt with masquet technique. Agarwal et al,^[5] treated such cases with fibular grafting, Tomar et al,^[6] used intramedullary nailing and grafting utilising periosteal sleeve.^[14]

But no systematic approach or protocol is there to deal with such cases which are increasing in number. Single bone reconstruction which was started long back to salvage the limb in adults, is still now done by many and has reported to give good results.^[18] Proximal ulna with distal radius, centralisation of ulna with arthrodesis, usage of vascularised fibula, free fibular graft for that has been reported to give good result with obvious sacrifice of pronation-supination. However, with fixation in mid-prone position, and available wide range of shoulder movement, and regaining some compensatory rotational movement at humero-ulnar joint particularly in children is seen with satisfactory functional outcome in most cases, and has been reported by different authors. But reconstruction of two bones will have obvious advantage of natural anatomical-functional benefits, so reconstruction of two bones, if possible is desirable. Different methods have been described in literature like bone grafting, bone transport, usage of masquet technique, osteo-periosteal vascularised composite autograft or allograft using fibula or by bone transport with ring fixator or limb reconstruction system.

However, in long standing cases of infected non-union of radius found mostly in third world countries, challenge of treatment is complex and complicated as delay in presentation adds multiple problems, compounded by limitation of expert surgical skill and socio-economic conditions. Problems of non-union and infection in these cases needs to be treated with simultaneous consideration of large gap, scarring with contracture-deformity, poor vascularity, muscular atrophy and fibrosis, osteoporosis and growth disturbances in growing bones. Gradual distraction can be overcome and treated with angiogenesis, histogenesis and Illizarov ring fixator with its biomechanical advantage with 360-degree control, best suited for paediatric population with its thin diameter wires providing excellent rigidity under tension. Significant inherent power of regeneration and remodelling can be utilized also as fibular graft is readily taken up, readily revascularized and gets incorporated. Cancellous grafts were added at the ends of fibula to promote union. Intra medullary wire fixation provided stability, which is much better than plating, which may interfere with

biology of graft and may increase chances of infection and bio-film formation. With tremendous power of regeneration in paediatric patients and thick periosteum, minimal fixation by wires or mini-fragment screws supplemented by biomechanical stability of Illizarov ring fixator provided adequate strength with mobility to achieve union on either side of fibula. No matchstick configuration to promote earlier osteo integration was adopted as fibula is well taken up in children and overlap at either end increased area of contact. That achieved union in all cases and adding cancellous graft at junctional areas to promote union was not needed.

Besides, histogenesis resulted in periosteal new bone formation (in one case excluded in this series that distraction resulted in union, bone grafting planned earlier was not needed), along with soft tissue regeneration including muscle: contracture and deformity was corrected with differential distraction, muscle mass increased – effectively dealing associated problem of development and disuse. Compared to two stage procedure of using JESS / mono-lateral fixator, tensioned wires provided needed stability and micro motion in these cases of associated osteoporosis. One stage reconstruction with thorough debridement with bone grafting reported to have good outcome, but has obvious disadvantage of persistent residual / increased chance of infection – which is definitely less with two stage procedure.

Single bone reconstruction is an age-old procedure is a good well established salvage procedure, but with obvious disadvantage of loss of pronation supination. With invention of distraction osteogenesis, osteosynthesis is much more predictable in such long standing infected non-union cases also.

Bone transport in forearm is definitely feasible and well documented by experienced “Illizarov surgeons”. But with so many nerves, vessels and muscles very few have done it in forearm for obvious concerns unlike tibia. Therefore, after radius is distracted to its anatomical level in relation to ulna, harvested fibula of appropriate length bridges the gap with 1 to 2 cm overlap with bevelled surface facing radius promoting union and also shortening the time in ring fixator and minimizing disadvantages of trans-fixation of soft tissues. Fibula is perforated in different plane for earlier incorporation. The procedure is easier compared to highly demanding expertise of vascularized fibular grafting which has definite advantage with disadvantages of higher cost and better infrastructure facilities.

However, larger multi-centric studies with longer follow-up are needed, RCT would have been better. DRUJ is not reduced anatomically and there were functional limitations – which is inevitable in such complex cases with long duration, though patients are happy as expectation is low.

CONCLUSION

Two stage procedure with stage I distraction by Ilizarov ring followed by fibular grafting in stage II is not only a good economical approach but also one of the best systematic approaches, which not only achieves union, control of infection but also addresses associated problems like deformity, contracture, developmental & disuse atrophy, osteoporosis and promotes early function & mobilisation.

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