



Research Article

A RETROGRADE COMPARATIVE STUDY COMPARING SINGLE VERSUS DOUBLE NANCY NAILS FOR FIXATION OF PEDIATRIC DIAPHYSEAL HUMERAL SHAFT

AliRedha Gerashi., Sadaf Mohammed Basheer., Mohammed Abdul Basith., Ahmed Abdul Hameed Aradi and Fatima Khamis Madan

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ABSTRACT

Back ground: Humeral shaft fractures are a rare occurrence in pediatrics population and both conservative and operative treatments remain a valid option of management, recently there has been a trend towards minimally invasive ESIN fixation techniques for such fractures to facilitate early rehabilitation, whether a single ESIN is sufficient for provision of stability required for bone healing or the usage of double ESIN is essential will be determined by our study

Objective: The aim of the study is to delineate any differences in the use of single or double ESIN for operative fixation of humeral shaft fractures in children 3-14 years of age.

Patients and methods: 23 pediatric patients ranging from 3-14 years were included in the study, with 13 being treated with double ESIN and in 10 single ESIN was utilized for fixation with relative surgical indications being unacceptable alignment, open type 1 fractures and polytrauma.

Results: All patients were followed for up to 1 year, radiographic union was seen in double ESIN in mean 4 weeks and in single ESIN group in mean of 6 weeks, both groups achieved full union and did not suffer any significant complications. The operative time for double ESIN was found to be more than single ESIN group which was statistically different as well.

Conclusions: In comparison of double versus single ESIN, our group favours the single ESIN as there was no difference in terms of union rates or time to union between the two groups with single ESIN group having the advantage of being low cost and utilizing less operative time.

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INTRODUCTION

Childhood humeral shaft fractures are rare injuries accounting only for 2-5% of the pediatric population^[1-3]. Most of the Fractures occur as a result of indirect trauma such as a fall on extended elbow, direct trauma in terms of RTA or crush injuries are also a described mechanism for such injuries^[1].

Historically these fractures have been treated conservatively due to the enormous remodeling capacity of the humerus which is unparalleled to any other growing bone in the body. Acceptable angulation in the humeral shaft fractures varies according to the age at presentation, whilst in infants and newborns, the upper limit is 35-45 degrees of angulation, in older children the recommendation is to limit the deformity to < 20 degrees of varus/valgus angulation, < 20 degrees of procurvatum, < 2 cm of shortening and < 15 degrees of rotational mal-alignment for middle 3rd^[1-2].

There is scarcity of literature on clear indications of operative treatment with absolute indications previously limited to open fractures and floating elbow type injuries with ipsilateral elbow and humerus fractures, nevertheless these fractures can be treated conservatively using functional brace/splints and hanging cast if the degree of angulation permits. However in older children as a result of high physical demand and unacceptable cosmetic appearance of an angulated humerus with socioeconomic aspects qualify as a valid indication for fixation in older children. Literature review suggests that surgical stabilization has been associated with improved fracture stabilization and maintenance of adequate alignment^[4].

In the recent years, nancy nail has been proposed as the preferred method for fixation of these fractures due to simplicity of the procedure. Complications associated with nancy nail are rare and when they occur, can be easily managed. ESIN insertion allows for shorter hospital stay and early return to activities of daily living.

*Corresponding author: AliRedha Gerashi

Most of the literature supports the use of ESIN in Diaphyseal Humerus fractures requiring 2 nancy nail for adequate stabilization though there have been isolated reports preferring the use of single nancy nail to provide adequate length and maintain the rotational alignment aided by the use of coaptation splint.

Our study aims at pointing the differences between usage of 2 Nancy nails versus a single nail technique in terms of variables such as operative time, hospital stay, time to callus formation and malalignment among others.

MATERIALS AND METHODS

A retrospective review of hospital records were performed for the patient undergoing nancy nailing of humeral shaft fractures from 2014-2019.

Inclusion Criteria: 23 patients qualified for inclusion criteria which included closed humeral shaft fractures, age from 3-14 years, polytrauma patients, gustillo type 1 fractures, patients in which adequate alignment could not be achieved following splint application.

Exclusion Criteria: All open gustillo type 2 and above fractures, floating elbow, fractures stabilized using K wires and pathological fractures were excluded.

Among 23 patients, 13 patients underwent stabilization of fracture using 2 Nancy nails whereas 10 patients were treated with single nancy nail. All patients were admitted via emergency system of the hospital after through clinical examination and proper AP and lateral radiographs. Interval to surgery was also recorded as an important predictor to final functional outcome. Other data regarding the method of reduction and Nail Sizes were obtained from patient's operative charts.

In our study no patient had pre or post op radial nerve palsy, 5 patients had gustillo type 1 open fracture.

Operative techniques

After systemic stabilization of the patients, they were taken to operative theater preferable within 48 hours of the trauma. ESIN were inserted according to established AO principles. Patients were placed in a supine position on radiolucent table with arm extension attached to the table. General anesthesia was administered and patient were prepped and draped in accordance to standard protocols. Initial attempts to closed reduction was preferred under fluoroscopic guidance. In cases of satisfactory reduction, we proceeded to ESIN insertion. Multiple attempts to obtain a closed reduction were avoided in order to limit the damage to radial nerve by sharp bony fragments, in these cases we proceeded to open reduction using a lateral approach centered over the fracture site. Each nail diameter was predetermined in accordance to the isthmus of the medullary canal to fit 40% of the affected medullary cavity in its narrowest point. Nails were selected in advance and pre-contoured in curved C shaped such that the apex of the curvature matches the fracture site for provision of optimal resistance.

Our technique utilizes the dual lateral entry portals, the so called unipolar ESIN technique for insertion of 2 nancy nails in a retrograde manner, for the lateral entry around 2 cm incision starting approximately 1cm from tip of lateral epicondyle was made. The incision was extended down to the

periosteum, anterior cortex was then perforated using bone awl after protection of soft tissues using retractors. Drill bits were avoided for this purpose, the selected nancy nail was then advanced using slight rotational movements. For the second nail, a lateral entry point was chosen proximal to the first entry site by 1-2 cm and extended to periosteum, near cortex was then perforated using Awl, another nail that was precontoured and of similar diameter is advanced keeping in mind that the total arc of rotation should not exceed 180 degrees to prevent corkscrew mechanisms which includes the two nails twisting around each other. After passage of the nail, the fracture fragment reduction and rotation is verified under C-arm, the nails are then cut and anchored in bony metaphysis, the skin is then closed using absorbable sutures.(Fig 1)

In case of single ESIN insertion , a lateral entry portal was utilized in a similar manner as described above, in this case the position of the nail was centered in the medullary cavity and appropriate nail diameter in this instance was determined to the 60% of the medullary isthmus and the sizes varied from 2.5 mm-4.5 mm (Fig 4)

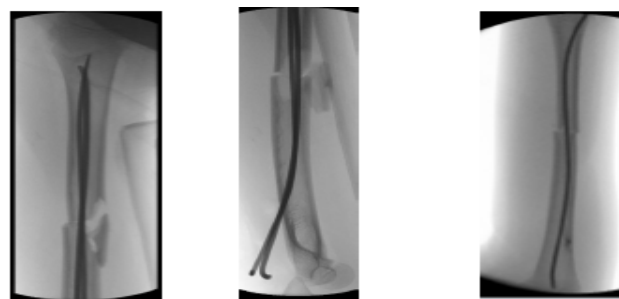


Fig 1 Unipolar entry of 2 lateral nails in a humeral shaft fracture

Follow-Up: In the immediate post-op period, patient was kept on above elbow slab posterior slab, and were reviewed in the clinic at 1 week with plain radiographs to check for any migration of the nail or secondary displacement. Radiographs were then repeated at 3 weeks and the slab was changed to functional brace for another 3 weeks. Radiographs were repeated at 3,6 and 12 months. Solid union was defined as callus formation involving 3 cortices in both AP and lateral views (Fig 2) .The nails were routinely removed after 6-12 months (Fig 3) and patients were followed up to 1 year post extraction of the nancy nail. Radiographs were not routinely obtained during follow-up visits.(Fig)



Fig 2 Complete union with callus bridging 3 cortices



Fig 3 Post removal of nancy nail



Fig 3 Post removal of nancy nail

Statistical analysis

Collected data were administered in excel sheet and processed, the confidence interval and P values were calculated with P value of < or equal to 0.05 were considered significant.

The functional outcomes were evaluated using DASH scores for shoulder function and disability, DASH scoring contains 2 components, the disability section and optional high performance-high work section.

Analysis of the statistics was done using Welch test for comparisons. Med Calc version 20.009 was used for analysis of confidence interval Radiographic union was graded according to Stans *et al* grading system (Table 1) which grades the presence of callus formation.

Stans *et al* scale for grading of callus formation

Table 1 Stans *et al* grading

Grade 0	No identifiable fracture healing.
Grade 1	Primary bone healing with little or no periosteal new bone formation.
Grade 2	Periosteal new bone formation on two sides of bone.
Grade 3	Periosteal new bone formation on three of four sides of bone.

RESULTS

23 patients met the inclusion criteria, for all the patients following data were collected: time of injury and time of surgery, hospital time, time to bone healing, time to removal of implant, functional status, grip strength, humeral length discrepancy, method of reduction and complications.

The average age of our patients was 9 years, the average time to surgery from trauma was noted to have 20 hrs.

The duration of procedure from induction of anesthesia to closure was noted to be 45-60 mins with mean of 52 mins in double nail group (Group 1) whereas in single entry nail group (Group 2) the mean time was 30 mins with ranges of 20-45 mins, this demonstrated as significant P-value of 1.0 and effect size of 1.8 between the groups in terms of operative time making it statistically significant.

Callus was initially noted in group 1 at an average of 3-7 weeks (mean 4 weeks) and in group 2 at 4-8 weeks (mean 6 weeks) and it was considered minimally significant.

The overall length of hospitalization was an average of 1.5 days (0-3 days) and was not affected by type of ESIN insertion.

In our study no pin migration were noticed, there was 1 case of hardware irritation as a result of which the patient was booked for early nail removal.

Routine removal of the nail was preferred at an average of 210 days (180-240 days) for group 1 and 215 days for (190-240) days for group 2, upon removal the patient was discharged 1st day post op without any significant complications. Both groups were followed for up to 1 year (0.15-1.92), all the patients had full ROM upon discharge from clinic and both groups scored equally on the DASH scores.

No significant complications were noted in our study in terms of radial nerve palsy, 2 of our cases developed superficial pin site infections that were treated with oral antibiotics. All cases reached no disability level.

DISCUSSION

Fractures involving the shaft of humerus are comparatively rare in paediatric population, these fractures are remarkable for their forgiving physiology as these fractures possess tremendous remodeling potential which is in part can compensate for any deformity as a result of malalignment, in addition the mobility of the shoulder makes any restriction of movement look trivial. The indication for non-op and operative treatment of humeral shaft fractures are not well established in literature.

Multiple studies have shown the efficacy of surgical stabilization in terms of aiding ambulation in polytrauma patients and better wound care but probably the greatest advantage that ESIN offers is the avoidance of prolonged immobilization whilst maintain adequate reduction thus broadening the horizon of indications for ESIN, for ESIN early mobilization is the rule and this aids in early return to school^[5]. The down side to the procedure includes 2nd surgery to remove the implant. The advantages of the procedure however outweigh the complications and therefore it is now considered as the recommended procedure for humeral shaft fracture in paediatric population.

ESIN may be regarded as the ideal procedure as it involves a short learning curve, minimal soft tissue stripping thereby preserving the fracture physiology in addition to providing stable fixation to aid in early ambulation and avoidance of prolonged immobilization. Understanding the propensity of technique is paramount in achieving good results.

The debate then arises so as for the utilization of single or double nancy nails for stabilization of the humeral shaft fractures, one might argue in favour of utilization of double nancy nail fixation due to theoretical biomechanical advantage in preventing displacement and rotation of double ESIN. Through our study we aimed at finding out whether there was any statistical difference in terms of healing between the double ESIN versus single ESIN group. To our surprise both groups healed within similar time frame with the single ESIN having certain advantages over the double ESIN group in terms of decrease in operative time with less blood loss and lower cost.

At our institution 23 patients underwent ESIN fixation for displaced humeral shaft fractures with 13 patients undergoing double nancy nail insertion and 10 patients undergoing a single nail insertion for stabilization of their fractures. The most common cause reported in our study was a fall on extended elbow resulting in humeral diaphyseal fractures which is in accordance to study conducted by Knorr *et al* where they reported similar distribution of causes for humeral shaft fractures^[6]. A strong male predominance was noted in our study which is in contrast to other studies where only a slight gender predominance was present, there was a greater propensity of right sided humeral shaft fracture in our study that is comparable to study by Zivanovic *et al*^[1].

Most of our patients underwent surgery within 24 hours as we presume that it is safe to postpone surgery by several hours in order to have proper anesthetic assessment provided that adequate immobilization and analgesic requirements are fulfilled.

The operative time for double nancy nail insertion was regarded as 83.1 mins in the study by Zivanovic *et al*^[1] which

is significantly more than our average of 35.3 minutes, this can be partially related to the recording of the time from induction of anesthesia to transfer of the patient to recovery room in contrast to our study where we calculated the time period from induction of anesthesia to wound closure and dressings. In a separate study by Ahmed *et al*^[7] the time duration for double nailing was recorded at 37 mins comparable to our time duration of 35.3 mins. The study by Ahmed *et al* showed significant difference in the operative timings of single nail versus double nailing^[7]. Our study revealed similar results with statistically significant differences. Single ESIN had shorted operative time periods with low costs.

The preferred configuration in our study of double ESIN was retrograde medial and lateral entry sites which was performed in all 13 patients. Zivanconi *et al*^[1] has favored this technique over dual lateral and ascending techniques reported in literature by Greg *et al*^[8] with main argument being an increase in operative times in dual techniques.

No neurological complaints occurred in our study in contrast to studies by Greg *et al*^[8] and Furlan *et al*^[9] both of which reported single cases of radial nerve neuropraxia that spontaneously resolved. In another study by Ahmed *et al*^[7], 3 cases of radial nerve neuropraxia were reported, 2 of which occurred in double nail group and 1 case was reported in single nail group.

2 of our cases developed superficial pin site infection that was treated with oral antibiotics, this was comparable to the infection rates mentioned in studies by Furqan *et al*^[9], Maruti *et al*^[10] and Greg *et al*^[8] that stand at <1%.

The average length of hospital stay in our study was 1.5 days whereas majority of these studies reported to have an average length of stay at 4.7 days. The duration of the stay was not affected by the presence of type 1 Gustilo open wound and these patients were discharged on oral antibiotics.

Most common nail size used was 2.5mm in majority of our patients though this data was mainly influenced by the age of the patient and whether a single or double ESIN was being used.

The age bracket of our study group did not influence the choice of double versus single ESIN. Standard retrograde insertion techniques is our preferred modality due to negligible complications in contrast to antegrade entry that carries the risk of rotator cuff damage during insertion and removal of the nail.

Displaced humeral shaft fractures can be best stabilized using ESIN, a displacement of > 20 degrees in any plane should be tried to be improved. It has been proven by multiple studies that ESIN provides adequate stability to the fracture thereby allowing sufficient time for healing by secondary intention without compromising the fracture biology.

CONCLUSION

Traumatic humeral shaft fractures rarely requires operative stabilization and when they do occur the ideal implant is ESIN providing adequate stable fixation and minimal soft tissue stripping.

Whether 2 Nancy nails construct is imperative for stability of the fracture or single ESIN provides sufficient stability to hold the reduction was the purpose of the study.

We concluded that the usage of single ESIN or double nail was associated with similar radiological and functional results but we found that single Nancy nail carried advantages over double ESIN. Theoretically the double nail construct provides more inherent stability to the fracture but we failed to prove statistical difference in this regards, moreover the insertion of double nail is technically demanding and has to be configured well in order to provide stability. On the contrary the insertion of single nail does not require much technicality. Single ESIN insertion was also associated with less operative time, post op pain scores and costs. Treating surgeon should be vigilant during follow up to assess for secondary displacement which is unrelated to presence of single or double ESIN.

There are certain limitations to our study including the small sample size, the lack of randomization and failure to address the confounding variables.

Our study favors the use of single ESIN to double Nancy nail for uncomplicated closed humeral diaphyseal fracture in pediatric population.

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