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Flexible Titanium Nailing versus Casting of Closed Unstable Tibial Shaft Fracture in Children and Adolescent

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Abstract

Background: Casting is the standard method of treatment for pediatric diaphyseal fracture of tibia. It has some limitations in treating an unstable fracture. Various options are available but still debate on optimal treatment strategy in 8-15 years age group. To compare the complications and Radiological Union of cast immobilization versus intramedullary nailing in the treatment of Children and adolescent with closed unstable tibial diaphyseal fractures.

Materials and methods: This is a Quasi-Experimental study and patients aged between 8 to 15 years with unstable closed fracture of tibial shaft came to the Department of Orthopedic Surgery of CMCH were included. Eligible patients were allocated according to inclusion criteria selected for fracture management either by closed reduction and cast immobilization or by flexible intramedullary nailing. Patients were followed-up for at least six months after surgery and casting. Outcome measures were radiological union, complications and functional outcome were assessed by Flynn's criteria at final follow-up. Data were collected with pretested structured case record form and analyzed by using SPSS-26 with appropriate statistical methods.

Results: Among58 patients, average mean ± SD age was 9.86 ± 1.91 (Range: 8-14) years. Most of the children (79.3%) were male in both groups. According to mode of injury, 72.4% was due to RTA. Associated fibular fracture was absent among 65.5% patients. According to types of fracture, short oblique was 58.6%, comminuted 17.2% and spiral 24.2%. There was no significant difference in complications among the two groups according to p value. Mean ± SD union time in nailing group was 10.56 ± 1.21 and in casting group was 10.46 ± 1.41 weeks. After 6 months follow up, in nailing group, 21 (80.8%) patient's functional outcome was excellent and 4 (15.4%) patient's functional outcome was satisfactory and 1(3.8%) poor. In casting group, 17 (65.4%) patient's functional outcome was excellent and 8 (30.8%) patient's functional outcome was satisfactory and. 1(3.8%) poor. Functional outcome was better in nailing group, but statistically non-significant (p=0.416).

Conclusion: Despite the popularity of casting in the treatment of tibial shaft fracture in children and adolescent, present study shows flexible titanium nailing is safe and effective surgical approach of treatment for closed unstable tibial shaft fracture in children and adolescent age group.

Key wotds: Children; Flexible titanium nailing; Unstable tibial shaft fractures.

Introduction

Tibia fractures are among the most common long-bone fractures in children.[1] Third most common pediatric long bone fracture after forearm bones and femur. The peak incidence occurs in children between the age of 10 and 14 years with an approximate 2:1 ratio of males to females injured. 70% of pediatric tibial fracture are isolated injuries, ipsilateral fibula fracture occur with 30% of tibial fracture. 51% occurred in distal third, 39% in middle third and 10% proximal third. 35% of pediatric tibial fracture is oblique, 32% comminuted, 20% transverse and 13% spiral.[2]

Fractures are commonly described by location, in the proximal, middle or distal thirds of the tibia, by associated injury, with or without an associated fibula fracture; and by fracture configuration: transverse, oblique, spiral, comminuted, or segmental. Fracture configuration is further defined by characterizing the associated deformity into valgus, varus, procurvatum, recurvatum, internal or external rotation and by the amount of displacement noted on the initial radiographs.[3]

The younger the child, the more accelerated the healing of a fracture will be. Most fractures can be

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treated conservatively. For rapid healing, the disadvantages of immobilization are less significant than in adults. However, conservative treatment may be associated with prolonged immobility, hospital stay and costs.[4]

Most tibial shaft fractures in pediatric patients have been traditionally treated with closed reduction and cast immobilization with good long-term outcomes.[5]

There are numerous publications defining treatment strategies of tibia shaft fractures in children and adolescents.[6,7]

The development of flexible intramedullary nails has allowed an increasing number of surgeons to use this type of nail for treating pediatric long bone fractures. There are several advantages of this technique. Three-point fixation with in the medullary canal allows maintenance of both alignments and rotation for most fractures. Flexible intramedullary nails provide fixation that is stable as well as elastic, allowing micro-motion at the fracture site when load is applied.[8]

Flexible intramedullary nails have recently gained more and more popularity in the treatment of tibia shaft fractures in pediatric patients who weigh less than 50 kg. RIN is advocated in heavier adolescents close to skeletal maturity.[9] However, children and adolescents with comminuted or unstable fractures may benefit from internal or external fixation.[10] Yet, open treatment of fractures does come with inherent risks. Painful hardware necessitating removal, deep infection requiring reoperation, persistent malalignment on final radiographs were complications documented among displaced fractures undergoing initial operative management.[11,12]

In this study both techniques-casting and flexible intramedullary nailing are being practiced for the management of closed unstable tibial shaft fracture in children and adolescent. This study is designed to compare outcomes of closed, unstable tibial shaft fractures in children and adolescents who will be subjected to closed reduction and casting versus those who will be treated with operative intervention by nailing (FINs).

In tibial shaft fracture,casting is the gold standard before 8 years and rigid intramedullary nail after 15 years. Though various options like casting, FINs, Plate fixation are available between this age group (8-15years) but no definite recommendation of ideal treatment strategy. Popularity of FINs has been increasing for last few years but casting is the mainstay of treatment in many center still now. Although both procedures have some advantages and limitations, it is very much rational and essential to evaluate and compare the outcome and complications of both techniques.

Materials and methods

This is a quasi experimental study was carried out in the Department of Orthopaedic and Traumatology, Chittagong Medical College Hospital (CMCH) Chattogram from August 2020 to July 2022. Children and Adolescent patients of unstable tibial diaphyseal fracture admitted during the study period. Purposive sampling done. Two groups of patients Group A: Underwent closed reduction and internal fixation by TENs and Group B: Underwent closed reduction and immobilization by casting were taken considering inclusion & exclusion criteria.

Total of 58 patients were selected. Patients with Age 8-15 years, closed unstable tibial diaphyseal fracture, displaced tibial shaft fracture that require reduction were included and open fracture, associated head injury, pathological fracture, tibial metaphyseal fracture were excluded.

Ethical clearance was obtained from the Ethical Review Committee (ERC) of CMCH,

Memo no- CMC/PG/2022/829, Date: 25/08/2020.

Image 1 Entry point of nail and placement of an awl that will create that entry point

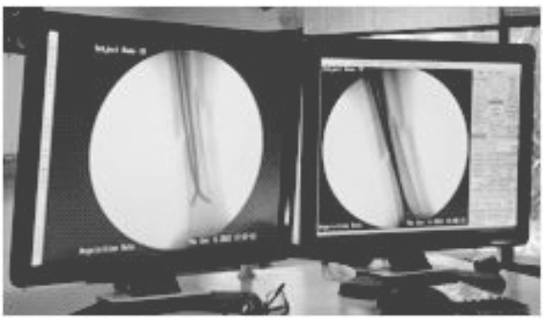

Image 2 Both nail crossed the fracture entered up to distal physis

Results

For this quasi-experimental study, a total number of 58 patients with unstable closed fracture of tibial shaft were selected on the basis of the inclusion and exclusion criteria. Three patient from each group were lost from the study. Final outcome was measured by using Flynn's criteria. All the data was compiled and sorted properly, analyzed statistically and placed.

Table I Demographic profile of the study population (n=58)

Age (Years)	Nailing (n=29)	Casting (n=29)	Total (n=58)	p value
Mean ± SD	10.28 ± 2.19	9.45 ± 1.53	9.86 ± 1.91	0.100#
Range	(Weeks) (8-14)	(8-13)	(8-14)	(ns)
Gender	n (%)	n (%)	n (%)	
Male	23 (79.3%)	23 (79.3%)	46 (79.3%)	1.00*
Female	6 (20.7%)	6 (20.7%)	6 (20.7%)	(ns)

Statistical analysis was done by student t-test (#) and Chi-square test (*).

Table II Distribution of the patients according to mode of injury, type of fracture and associated fibular fracture with type of management (n=58)

Pattern of injury	Nailing n	Nailing %	Casting n	Casting %	Total n	Total %	p value
Type of fracture							
short oblique	19	65.5	15	51.7	34	58.6	
Comminuted	4	13.8	6	20.7	10	17.2	0.175ns
Spiral	6	20.7	8	27.6	14	24.2	
Mode of injury							
RTA	22	75.9	20	69.0	42	72.4	0.557ns
Fall from height	7	24.1	9	31.0	16	27.6	
Associated Fibular fracture							
Present	9	31.0	11	37.9	20	34.5	0.581ns
Absent	20	69.0	18	62.1	38	65.5.	

● Statistical analysis was done by Chi-square test.

Table III Post-operative final follow-up outcome (n=52)

Outcome	Nailing n	Nailing %	Casting n	Casting %	Total n	Total %	p value
Limb length discrepancy							
No	26	100	26	100	52	100	
Yes	0	0	0	0	0	0	---
Malalignment							
No	22	84.6	17	65.4	39	75	
Varus	2	7.7	5	19.2	7	13.5	0.136ns
Valgus	2	7.7	4	15.4	6	11.5	
Unresolved pain							
Absent	26	100	26	100	52	100	
Present	0	0	0	0	0	0	…..
Complications							
No	19	73.2	17	65.4	36	69.3	
Varus angulation	2	7.7	5	19.2	7	13.5	
Valgus angulation	2	7.7	4	15.4	6	11.5	0.408ns
Superficial infections	1	3.8	0	0	1	1.9	
Deep infection	1	3.8	0	0	1	1.9	
Delayed union	1	3.8	0	0	1	1.9	

● Statistical analysis was done by Chi-square test.

Table IV Functional outcome after 2 weeks (n=58), 4 weeks (n=58), 8 weeks (n=56) and 3 months (n=55)

Outcome	Nailing n	Nailing %	Casting n	Casting %	Total n	Total %	p value
After 2 weeks							
Poor	0	0	2	6.9	2	3.4	
Satisfactory	29	100	27	93.10	56	96.6	0.352ns
Excellent	0	0	0	0	0	0	
After 4 weeks							
Poor	1	3.4	2	6.9	3	5.2	
Satisfactory	28	96.6	27	93.1	55	94.8	0.469ns
Excellent	0	0	0	0	0	0	
After 8 weeks							
Poor	1	3.6	1	3.6	2	3.6	
Satisfactory	3	10.7	8	28.5	11	19.6	0.229ns
Excellent	24	85.7	19	67.9	43	76.8	
After 3 months							
Poor	1	3.6	1	3.7	2	3.6	
Satisfactory	4	14.3	8	29.6	12	21.8	0.230ns
Excellent	23	82.1	18	66.7	41	74.6	

● Statistical analysis was done by Chi-square test.

Figure 1 Patients according to functional outcome at 6 months final follow up (n=52)

Discussion

Conservative treatment is considered ideal for tibial diaphyseal fracture in children and adolescents for a long time due to avoidance of surgical intervention and it's associated complication. Different studies suggest that unstable tibial diaphyseal fracture with conservative management fails at a high rate and usually ends up with displacement, malrotation and malunion.[13] Despite their recommendation, there is no published reports directly comparing the outcome of cast immobilization for closed pediatric tibial fracture with those of surgical stabilization.[14]

This study includes 58 patients, 6 of them dropped out in the middle of the follow up. Group-A, patients treated with closed reduction and internal fixation by TENs (Double C Construct) and Group-B, patient treated with closed reduction and immobilization by casting. Final outcome of both procedure was determined using Flynn's criteria at 6 months.

The results of current study demonstrate, average mean ± SD age was 9.86 ± 1.91 (Range: 8-14) years. According to p value (< 0.05) indicates, age of the children was statistically higher in nailing group. Similarly, found the average age of the patients was 11.3 (Range 6 to 14) years.[15] Another study by reported the 20 patients comprised with a mean age at injury of 8.9 ± 2.78 (Range of 3–14) years revealed mean age at injury was 11 years and 5 days (Range of 8–17 years).[16]

Present study shows, among 58 patients, most of the children (79.3%) were male inboth groups. According to p value statistically no significant differences were found between the groups regarding gender. Male prominence was found in a study, 85.1% male (63/74).[17] Similarly, male prominence was found in thestudy.[18] The 20 patients comprised of 16 (80%) boys and4 (20%) girls. also found 17(68%) boys and 8 (32%) girls, in their study.[18] Another study describe that, there were 92 (69.7%) boys and 40 (30.3%) girls.[18]

Regarding the type of injury, out of 58 cases, 58.6% patients had short oblique fracture and 17.2% patients had comminuted fracture and 24.2% patient had spiral fracture. Non-significant difference was found in case of type of fracture among the group (p=.175).

Associated fibular fracture was absent among 65.5% patients in present study. NoSignificant difference between nailing and casting groups according to associatedfibular fracture (p=0.581) in present study.

Among 52 patients at final follow up at 6 months, in case of TENs (26)7 patients develop complication (Table-III). 1 patient developed superficial infection (3.8%), 1 patient developed deep infection (3.8%), 1 developed delayed union (3.8%), 2 valgus angulation (7.7%), 2 varus angulation (7.7%). In case of casting (26) 9 patients develop complications (Table III). 4 patients develop valgus angulation (15.4%) and 5 patients develop varus angulation (19.2%). There was no significant difference incomplications among the two groups according to p value. A study revealed the operative group had a lower proportion of inadequate alignment at final follow up (7%) compared with those with CRC (21%). Another study revealed, no patient had an angulation of over 10 and 9 (45%) patients had anangulation of 5–10. One patient had a leg-length inequality of 10 mm, 2 of them had superficial wound infections and the other patient had a deep wound infection.[19]

A study published that 10% of there pediatric tibia fracture treated with flexible nails had angular deformity >10 degree and similarly reported a 12% rate of malangulation >10 degree. In a report, in children andadolescent casted tibias was 5% rate of angulation >5 degree in coronal plane and 3%rate of angulation >10 degree in sagittal plane.[19,20] Another study found angular deformity in 2 patients and superficial infection 2 patients. A study reviewed the complications TENs, he found angular malunion and limb length discrepancy are relatively common whereas rotational misalignment is quite uncommon.[21,22] Superficial infection was controlled by debridement, irrigation, antibiotic according toculture sensitivity and retention of the implant. Deep infection was managed with debridement, irrigation, antibiotic according to culture sensitivity and retention of implant. But it remains unresolved. Thereafter managed by removal of implant after 6 weeks, wound debridement, irrigation, serial dressing. Intravenous antibiotic was given according to culture sensitivity. Inj cefuroxime 750 mg T.D.S continued for 2 weeks

followed by oral antibiotic (Tab Ciprofloxacin 250 mg BD and Cap Clindamycin 150 mg T.D.S) for another 6 weeks. When CRP and ESR appeared normal, long leg cast was given for 4 weeks followed by a patellar weight-bearing cast for another 4 weeks. Here radiological union achieved after 24 weeks.

Finally the outcome was determined by Flynn's criteria. Table IV shows, functional outcome after 2 weeks, 4 weeks, 8 weeks and 3 months. There were no significantdifferences among the two groups according to p value regarding functional outcome. After 6 months follow up, among 52 patients, 38 (73.1%) patient's functional outcome was excellent and 12 (23.1%) patient's functional outcome was satisfactory and 2(3.8%) poor. In nailing group, 21 (80.8%) patient's functional outcome was excellent and 4 (15.4%) patient's functional outcome was satisfactory and 1(3.8%) poor. Incasting group, 17 (65.4%) patient's functional outcome was excellent and 8 (30.8%) patient's functional outcome was satisfactory and 1(3.8%) poor. Functional outcomewas better in nailing group, but statistically non-significant (p=0.416) (Figure 1).[23]

Another study shows among 19 patients 13 (68.42%) has excellent result, 5 (26.31%) satisfactory and 1 (5.26%) patient has poor result.[24] In other study, the final outcome based on titanium elastic nailing outcome scoring system by Flynn are as follows.[25] They had 18 excellent results, 4 satisfactory results and no poor results. Another study, also stated that according to Flynn's criteria, 12 (60%) patients had an excellent outcome and 8 (40%) patients had a satisfactory outcome.[26] Another study, described that according to Flynn's criteria, 16 (64%) patients had an excellentoutcome and 9 (36%) patients had a satisfactory outcome.[27] Another study also found, according to the scoringcriteria for ESINs by Flynn, 15 (75%) cases had excellent results.[28,20]

Although no statistically significant difference was not found between the treatment modalities, Flexible Titanium Nailing shows better outcome than casting in present study.

Limitations

The study was conducted as a single center study, so multicentric study will be more acceptable. Patients admitted after mal treatment was not eligible for operative treatment Small sample size which is not represent the actual scenario of the country.

Conclusion

Despite the popularity of casting in the treatment of tibial shaft fracture in children and adolescent, present study shows flexible titanium nailing is safe and effective surgical approach of treatment for closed unstable tibial shaft fracture in children and adolescent age group.

Recommendations

To make more conclusive results some recommendations are proposed for further studies. Similar type of study can be done with large sample size, to represent whole community, multicentric study can be done, RCT and blinding should be done to avoid bias in the study.

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Contribution of authors

AKG-Conception, acquisition of data, drafting & final approval.

MAH-Design, data analysis, critical revision & final approval.

KIA-Interpretation of data, critical revision & final approval.

SAI-Data analysis, critical revision & final approval.

SB-Data analysis, critical revision & final approval.

MSRC-Acquisition of data, drafting & final approval.

MH-Acquisition of data, drafting & final approval.

SG-Acquisition of data, drafting & final approval.

Disclosure

All the authors declared no competing interest

References

1. Duan X, Al Qwbani M, Zeng Y, Zhang W, Xiang Z. Intramedullary nailing for tibial shaft fractures in adults. Cochrane Database of Systematic Reviews. 2012(1).

2. Economedes DM, Abzug JM, Paryavi E, Herman MJ. Outcomes using titanium elastic nails for open and closed pediatric tibia fractures. Orthopedics. 2014;37(7):e619-e6224.

3. Ahmed KE, Zakaria B, Hadhood M, Shaheen A. Management of diaphysealtibial fracture in pediatrics by elastic stable intramedullary nails. Menoufia Medical Journal. 2014;27(2):401.

4. Goodwin RC, Gaynor T, Mahar A, Oka R, Lalonde FD. Intramedullary flexible nail fixation of unstable pediatric tibial diaphyseal fractures. Journal of Pediatric Orthopaedics. 2005;25(5):570-576.

5. O'Donnell C, Foster J, Mooney R, Beebe C, Donaldson N, Heare T. Congenital pseudarthrosis of the tibia. JBJS reviews. 2017;5(4):e3.

6. Griffet J, Leroux J, Boudjouraf N, Abou-Daher A, El Hayek T. Elastic stable intramedullary nailing of tibial shaft fractures in children. Journal of children's orthopaedics. 2011;5(4):297-304.

7. Herman MJ, Martinek MA, Abzug JM. Complications of tibial eminence and diaphyseal fractures in children: prevention and treatment. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2014;22(11):730-741.

8. Ho CA, Dammann G, Podeszwa DA, Levy J. Tibial shaft fractures in adolescents: analysis of cast treatment successes and failures. Journal of Pediatric Orthopaedics B. 2015;24(2):114-117.

9. Kinney MC, Nagle D, Bastrom T, Linn MS, Schwartz AK, Pennock AT. Operative versus conservative management of displaced tibial shaft fracture in adolescents. Journal of Pediatric Orthopaedics. 2016;36(7):661-666.

10. Larsen P, Elsoe R, Hansen SH, Graven-Nielsen T, Laessoe U, Rasmussen S. Incidence and epidemiology of tibial shaft fractures. Injury. 2015;46(4):746-750.

11. Mashru RP, Herman MJ, Pizzutillo PD. Tibial shaft fractures in children and adolescents. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2005;13(5):345-352.

12. Mooney JF, Hennrikus WL. Fractures of the shaft of the tibia and fibula. InRockwood & Wilkins Fractures in Children: Eighth Edition. Wolters Kluwer Health Adis (ESP). 2014.

13. Nau C, Marzi I, Ziebarth K, Berger S. Fractures in children and adolescents. Intramedullary Nailing: A Comprehensive Guide. 2015;395-417.

14. Onta PR, Thapa P, Sapkota K, Ranjeet N, Kishore A, Gupta M. Outcome of diaphyseal fracture of tibia treated with flexible intramedullary nailing in pediatrics age group : A prospective study. Am. J. Public Health. 2015;3:65-68.

15. Palmu SA, Auro S, Lohman M, Paukku RT, Peltonen JI, Nietosvaara Y. Tibial fractures in children: A retrospective 27-year follow-up study. Acta Orthopaedica. 2014;85(5):513-517.

16. Patel NK, Horstman J, Kuester V, Sambandam S, Mounasamy V. Pediatric tibial shaft fractures. Indian journal of orthopaedics. 2018;52:522-528.

17. Pogoreli 18. Z, Vegan V, Juki 19. M, Llorente Muñoz CM, Furlan D. Elastic Stable Intramedullary Nailing for Treatment of Pediatric Tibial Fractures: A 20-Year Single Center Experience of 132 Cases. Children. 2022;9(6):845.

18. Raducha JE, Swarup I, Schachne JM, Cruz Jr AI, Fabricant PD. Tibial shaft fractures in children and adolescents. JBJS reviews. 2019;7(2):e4.

19. Ramalingam WG, Carry P, Brazell C, Calkins R, Linza-Moscati S, Stoneback J, Miller NH. Outcomes of displaced adolescent distal third tibia fractures: Can we do better?. Journal of Pediatric Orthopaedics B. 2022;31(2):e147-153.

20. Rockwood CA. Rockwood and Wilkins' fractures in children. Lippincott Williams & Wilkins. 2010.

21. Sahu RL, Ahmed N. Titanium elastic percutaneous nails for pediatric long bone shaft fractures: current concept. Bangladesh Journal of Medical Science. 2017;16(1):61.

22. Sankar WN, Jones KJ, David Horn B, Wells L. Titanium elastic nails for pediatric tibial shaft fractures. Journal of children's orthopaedics. 2007;1(5):281-286.

23. Shen K, Cai H, Wang Z, Xu Y. Elastic stable intramedullary nailing for severely displaced distal tibial fractures in children. Medicine. 2016;95(39).

24. Stenroos A, Puhakka J, Nietosvaara Y, Kosola J. Treatment of closed tibia shaft fractures in children: A systematic review and meta-analysis. European Journal of Pediatric Surgery. 2019;30(06):483-489.

25. Thabet AM, Craft M, Pisquiy J, Jeon S, Abdelgawad A, Azzam W. Tibial shaft fractures in the adolescents: Treatment outcomes and the risk factors for complications. Injury. 2022;53(2):706-712.

26. Thompson JC, Netter FH. Netter's concise atlas of orthopaedic anatomy. (No Title). 2002.

27. Uluda A, Tosun HB. Treatment of unstable pediatric tibial shaft fractures with titanium elastic nails. Medicina. 2019;55(6):266.

28. Vallamshetla VR, De Silva U, Bache CE, Gibbons PJ. Flexible intramedullary nails for unstable fractures of the tibia in children: An eight-year experience. The Journal of Bone & Joint Surgery British Volume. 2006;88(4):536-540.

29. Whelan DB, Bhandari M, Stephen D, Kreder H, McKee MD, Zdero R, Schemitsch EH. Development of the radiographic union score for tibial fractures for the assessment of tibial fracture healing after intramedullary fixation. Journal of Trauma and Acute Care Surgery. 2010;68(3):629-632.