The use of the reconstruction plate in multiplanar tibial osteotomies in children

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Abstract

Purpose External fixation and cross-pin fixation appear to be the two most commonly used forms of fixation after a tibial osteotomy in children described in the literature. The purpose of this study is to describe our experience using a properly bent and contoured reconstruction plate for mismatched surfaces after a multiplanar tibial osteotomy.

Methods A retrospective review was conducted of 37 multiplanar tibial osteotomy surgeries in 23 children performed by a single surgeon using a reconstruction plate for internal fixation. A low fibular osteotomy and tibial osteotomy that required contouring and shaping of the plate were performed in all cases. A proximal tibial osteotomy was performed in 30 cases and a distal osteotomy in seven cases. All cases were reinforced with a long-leg cast. All charts were reviewed for intra- and postoperative complications. The surgery using the reconstruction plate internal

fixation was considered to be a success if there was healing of the osteotomy and no hardware failure.

Results A properly bent and contoured reconstruction plate conformed well to the mismatched surfaces after tibial osteotomy. Hardware was removed in all but two cases, on average 7 months after surgery. There were no hardware failures. No child developed a deep wound infection or neurovascular complication, including compartment syndrome. Only two complications in 37 surgeries (5%) were encountered and were typical of any type of internal fixation. One child required an exploratory procedure because of screw extrusion and one child developed a post-plate removal fracture.

Conclusions The reconstruction plate is very malleable and can be contoured to fit in nearly every direction to accommodate mismatched appositional surfaces. It has been successfully employed in 37 consecutive cases of multiplanar tibial osteotomy in children with relatively few complications, none directly related to the plate.

Study conducted at Akron Children's Hospital.

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Introduction

External fixation and cross-pin fixation appear to be the two most commonly used forms of fixation after a tibial osteotomy in children described in the literature. Many series have demonstrated a high rate of complications regardless of fixation type in tibial osteotomies in children [1–5]. Pinkowski and Weiner [2] and Slawski et al. [1] have also described techniques to minimize complications in tibial osteotomies. The ideal method of fixation for these osteotomies has yet to be defined within the orthopedic literature. There have been reports of loss of fixation with

Table 1 Characteristics and complications of children included in the study

Study no.	Sex	Side	Diagnosis	Deformity	Tibial surgery location	Age at surgery (years)	Length of follow-up (years)	Plate removed (months)	Complications
1.1	M	R	Postseptic growth plate closure	Varus + torsion	Proximal	6.3	4.8	5.6	None
1.2	M	L	Postseptic growth plate closure	Varus + torsion	Distal	6.8	4.4	7.5	None
2	F	R	Blount	Varus + torsion	Proximal	3.5	2.5	N/A	Plate encapsulated, only screw was removed
3.1	M	L	Growth plate arrested vascular	Equinus + torsion	Distal	4.6	7.4	8.1	None
3.2	M	L	Growth plate arrested vascular	Equinus + varus	Distal	6.9	5.1	7.5	None
4	M	L	Arthrogryposis	Equinus + cavovarus	Distal	5.6	4.9	N/A	Plate not removed
5.1	M	L	Achondroplasia	Varus + torsion	Proximal	2.6	1.6	8.4	None
5.2	M	R	Achondroplasia	Varus + torsion	Proximal	2.6	1.6	8.5	None
6	M	L	Vater syndrome	Equinus + varus	Distal	5.0	2.2	6.7	None
7	M	L	Pseudoachondroplasia	Varus + torsion	Proximal	13.0	1.4	7.9	None
8.1	F	L	Achondroplasia	Varus + torsion	Proximal	8.5	2.1	6.4	None
8.2	F	R	Achondroplasia	Varus + torsion	Proximal	10.1	0.5	5.8	None
9.1	M	R	Achondroplasia	Varus + torsion	Proximal	3.9	1.5	7.8	None
9.2	M	L	Achondroplasia	Varus + torsion	Proximal	3.9	1.5	7.7	None
10.1	M	L	Achondroplasia	Varus + torsion	Proximal	3.3	1.8	10.5	None
10.2	M	R	Achondroplasia	Varus + torsion	Proximal	3.7	1.3	4.9	None
11	M	L	Clubfoot	Equinus + torsion	Distal	12.5	2.4	7.9	None
12.1	M	R	Achondroplasia	Varus + torsion	Proximal	5.4	1.4	7.2	None
12.2	M	L	Achondroplasia	Varus + torsion	Proximal	5.4	1.3	7.2	None
13.1	F	R	Achondroplasia	Varus + torsion	Proximal	10.7	0.6	7.0	None
13.2	F	L	Achondroplasia	Varus + torsion	Proximal	10.7	0.6	7.0	None
14	F	R	Cartilage–hair hypoplasia	Varus + torsion	Proximal	12.1	3.6	6.4	None
15.1	M	L	Rickets	Varus + procurvatum	Proximal	4.8	5.7	4.0	None
15.2	M	R	Rickets	Varus + procurvatum	Proximal	5.1	5.3	10.7	None
16.1	F	R	Cartilage–hair hypoplasia	Varus + torsion	Proximal	10.3	0.8	6.3	None
16.2	F	L	Cartilage–hair hypoplasia	Varus + torsion	Proximal	10.4	0.8	6.2	None
17	F	L	Clubfoot	Equinus + torsion	Distal	8.9	1.2	13.8	Screw extruded, required exploratory osteotomy
18	F	L	Blount	Varus + torsion	Proximal	4.9	0.5	5.6	None
19.1	F	L	Achondroplasia	Varus + torsion	Proximal	6.5	0.6	6.8	None
19.2	F	R	Achondroplasia	Varus + torsion	Proximal	6.5	0.6	6.7	None
20.1	M	L	Achondroplasia	Varus + torsion	Proximal	15.0	1.4	10.3	None
20.2	M	R	Achondroplasia	Varus + torsion	Proximal	15.3	1.1	6.1	None
21	M	L	Achondroplasia	Varus + torsion	Proximal	13.3	0.9	4.6	None
22.1	M	R	Kyphomelic dysplasia	Varus + torsion	Proximal	2.4	2.1	4.2	None
22.2	M	L	Kyphomelic dysplasia	Varus + torsion	Proximal	2.4	2.1	4.1	Post-plate removal fracture
23.1	F	R	Achondroplasia	Varus + torsion	Proximal	5.8	1.0	6.5	None
23.2	F	L	Achondroplasia	Varus + torsion	Proximal	5.8	1.0	6.5	None

N/A not applicable; M male; F female; R right; L left

cross-pin fixation, and external fixation typically incurs a very high equipment cost to the institution and a significant incidence of pin tract infections [3, 4, 6, 7]. The purpose of

this study is to describe our experience using a properly bent and contoured reconstruction plate for mismatched surfaces after multiplanar tibial osteotomy.

Fig. 1 Drawing of a proximal tibial multiplanar osteotomy with a low fibular osteotomy. **a** Surgical cuts made. **b** Fixation with the reconstruction plate

Materials and methods

A retrospective review was conducted of all tibial osteotomy surgeries performed on children by a single surgeon (D.S.W.) using a reconstruction plate for fixation from March 2000 to January 2008. Thirty-seven surgeries in 23 children (14 boys, 9 girls) were identified and included. Fourteen children had bilateral surgeries. The right leg was involved in 15 cases and the left leg in 22 cases. The average age at surgery was 7.2 years (range 2.4–15.3 years). A minimum of 6 months follow-up was used for inclusion in this study to allow for the evaluation of healing. The average follow-up was 2.2 years (range 6 months–7.4 years). The underlying diagnosis included achondroplasia ($n = 19$), cartilage–hair hypoplasia ($n = 3$), clubfoot ($n = 2$), and various other disorders, such as arthrogryposis, Blount's disease, rickets, kyphomelic dysplasia, pseudoachondroplasia, Vater syndrome, postseptic growth plate closure, and growth plate arrest due to vascular causes (Table 1). The deformities corrected included 29 varus plus torsion deformities, three equinus plus torsion deformities, and various others, such as varus plus procurvatum, equinus plus varus, and equinus plus cavovarus (Table 1). A low fibular osteotomy and tibial osteotomy that required contouring and shaping of the plate were performed in all cases. A proximal tibial osteotomy was performed in 30 cases and a distal osteotomy in seven cases. All charts were reviewed for intra- and postoperative complications. The surgery using the reconstruction plate internal fixation was considered to be a success if there was healing of the tibial osteotomy and no hardware failure.

Fig. 2 Frontal and side views of: **a** locking AO plate, **b** unlocked AO plate, **c** reconstruction plate

Operative technique

All surgeries were performed under the direct supervision of the senior surgeon (D.S.W.). A tibial multiplanar osteotomy was performed in conjunction with a low fibular osteotomy in all cases. A proximal tibial osteotomy was performed in 30 cases (Fig. 1) and a distal tibial osteotomy in seven cases. A bent and contoured reconstruction plate (Fig. 2) were used for fixation with at least two cortical screws (usually three) proximal and distal to the osteotomy. An anterior compartment release was performed in all cases. All patients were placed in a long-leg cast. The average room time for the procedure, including anesthesia, regional anesthetic blocks, and patient preparation time, was 99 min (range 50–175 min). The average case time for the procedure itself was 69 min (range 25–125 min).

Results

A properly bent and contoured reconstruction plate conformed well to mismatched surfaces after tibial osteotomy in all 37 cases evaluated. The long-leg cast was removed, on average, 8 weeks after surgery. Patients were routinely followed after surgery until radiographic healing occurred, which averaged 4.3 months (range 1.8–9.3 months), and occurred in all cases (Figs. 3, 4, 5, and 6). Deformity correction obtained at the time of surgery was maintained at the last follow-up in all cases. Return to activity was predicated on evidence of radiographic healing. Hardware was removed, on average, 7.1 months after surgery and was removed in all but two cases. In one case, the plate was left in a child with arthrogryposis. In another case, only the screws were removed because the plate was enveloped within the surrounding bone.

Fig. 3 Radiographs of the right leg of a 10-year-old girl with cartilage–hair hypoplasia and a varus and severe torsion deformity of the tibia. **a** Preoperative anterior–posterior view. **b** Preoperative lateral view. **c** Postoperative anterior–posterior view. **d** Postoperative lateral view. **e** Healed anterior–posterior view after plate removal. **f** Healed lateral view after plate removal

Fig. 4 Radiographs of the left leg of a 10-year-old girl with cartilage–hair hypoplasia and a varus and severe torsion deformity of the tibia. **a** Preoperative anterior–posterior view. **b** Preoperative lateral view. **c** Postoperative anterior–posterior view. **d** Postoperative lateral view. **e** Healed anterior–posterior view after plate removal. **f** Healed lateral view after plate removal

Fig. 5 Radiographs of the right leg of a 5-year-old girl with achondroplasia and a varus and severe torsion deformity of the tibia. **a** Preoperative anterior–posterior view. **b** Preoperative lateral view.

c Postoperative anterior–posterior view. **d** Postoperative lateral view. **e** After plate removal anterior–posterior view. **f** After plate removal lateral view. **g** Healed anterior–posterior view. **h** Healed lateral view

There were no hardware failures. No child developed a deep wound infection or other neurovascular complication, including compartment syndrome. Only two complications in 37 surgeries (5%) were noted and were typical of any type of internal fixation. One child required an exploratory procedure approximately 2 weeks after surgery because one of the screws was extruding. Another child developed a post-plate removal fracture approximately 4 months after plate removal.

Discussion

The ideal form of fixation of pediatric multiplanar tibial osteotomies remains controversial. Compared to other previous reports in the pediatric orthopedic literature, we believe that our overall complication rate (5%) is very low. No child developed a neurovascular complication or deep wound infection. Rates on peroneal nerve palsies

cited in the literature [1, 2, 8] have ranged from 4.3 to 26.3%. Payman et al. [9] reported a 27% rate of wound complications in a series of tibial osteotomies, while Wilson et al. [4] reported a rate of 73.7% (including pin site infections). Although our series did not include many of the comorbidities associated with patients with Blount's disease, no patient in our series experienced a deep infection.

In our series, the reconstruction plate was not associated with any hardware failures. We believe that the malleability of this particular plate is ideally suited to this type of surgery, where mismatched surfaces need to be apposed (Fig. 2). The use of the reconstruction plate allows for the implant to be buried beneath the skin, avoiding pin tract infections. While likely not as strong as other orthopedic implants, in this pediatric population, applied in conjunction with a long-leg cast, the fixation is more than adequate to allow maintenance of the surgical positions and eventual healing of the osteotomy.

Fig. 6 Radiographs of the right leg of a 5-year-old with achondroplasia and a varus and severe torsion deformity of the tibia. **a** Preoperative anterior–posterior view. **b** Preoperative lateral view.

c Postoperative anterior–posterior view. **d** Postoperative lateral view. **e** After plate removal anterior–posterior view. **f** After plate removal lateral view. **g** Healed anterior–posterior view. **h** Healed lateral view

The plate is placed subperiosteally and there is a variable degree of periosteal stripping involved with inserting the plate. It is recognized that such stripping may delay bone healing; but, in this series, this did not occur and is very unlikely to occur in a pediatric population unless full circumferential stripping is performed.

Although cross-pin fixation with the ends of the pins bent and left subcutaneously is certainly a reasonable technique, cross-pins or external fixators where the pins are left out of the skin increase the risk of pin tract infection. We believe that our technique presented using the malleable plate is an alternative and preferable method of fixation. The cast application as presented provides additional protection to prevent displacement of the osteotomy.

We believe that this method of fixation may allow for significant cost savings for our institution. Although there are additional operative costs associated with plate removal, significant hardware savings are realized. At our institution, a seven-hole reconstruction plate currently costs \$817. The simplest external fixator with four pins, four clamps, and

one strut costs \$3,800. A multi-ring spatial frame averages over \$20,000 in cost to our hospital. External fixation obviously allows for easier hardware removal upon healing. The use of the external fixator must be weighed against pin site infection, which has been quoted to be as high as 48% in some series, as well as costs [4, 9].

Conclusion

The reconstruction plate is very malleable and can be contoured to fit in nearly every direction to accommodate mismatched appositional surfaces. It has been successfully employed in 37 consecutive cases of multiplanar tibial osteotomy in children with relatively few complications, none directly related to the plate.

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