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Repeated intramedullary stabilization following failed telescopic nail lengthening – An appropriate treatment strategy

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ABSTRACT

Externally magnetic-controlled intramedullary telescopic nails for bone lengthening have recently gained popularity due to many advantages when compared to more traditional lengthening methods. Patients requiring lengthening often present with a clinical history of previous multiple surgeries increasing the risk for complications of further procedures. However, studies regarding the treatment of complications following implantation of these devices remain scarce in literature. Therefore, we report our experience with revision surgery after lengthening with a telescopic intramedullary lengthening nail. In 6 out of 20 cases (30%) of lower limb lengthening for leg length discrepancy revision surgery was necessary. Two revisions were necessary due to nail breakage while the other 4 cases required a secondary procedure for non-union. In all cases, revision surgery included standard intramedullary locking nailing with additional autologous bone grafting. The median interval between index and revision surgery was 11.5 months (range 2–15 months). Satisfying clinical results, the intended extend of lengthening and bony consolidation was observed in all 6 patients. We conclude that revision surgery using an intramedullary locking nail with autologous bone grafting after failed telescopic nail-based lengthening represents an useful salvage procedure in these cases.

Introduction

Internal implants for bone lengthening have gained popularity during recent years. Development of intramedullary lengthening nails (ILN) with magnetic driven, externally controlled mechanisms improved patient satisfaction and applicability [1–4]. Furthermore, ILNs lack known complications of externally applied lengthening devices, e.g. the Ilizarov frame, including pin-tract infections, scarring, and pain caused by soft-tissue irritation [5,6]. In contrast, ILNs do not allow for axis correction during the follow-up period. Also, reliability of distraction control and implant stability, especially at the lengthening site of available intramedullary implants, has been controversially discussed since their release [3,7–9]. Literature offers numerous reports of complications of this implant type including nerve lesions, implant breakage, loss of distraction controllability, and joint stiffness. We have recently reported high complication rates in patients treated with ILNs in accordance with other authors [2,10–12]. Various factors causing delayed and/or non-union have been described irrespective of used devices. In literature both distraction rate and bone quality are discussed as primary factors influencing bone regeneration and healing in limb lengthening [13]. Considering the high popularity of ILNs in the treatment of leg length discrepancy (LLD), surgeons need to expect an increasing incidence of associated complications. Especially, since most of these patients underwent previous surgical procedures the risk of complications of future procedures including infections and non-union might be increased [9,12,14,15]. Treatment of these cases often presents a challenge for numerous reasons with limited literature available discussing these issues. The aim of this study was therefore to summarize our experience in the treatment of patients with ILN-lengthening associated complications using repeated intramedullary stabilization.

Methods

Patients and index surgery

We started performing intramedullary lengthening in 2013 using the PRECISE® intramedullary limb lengthening system (NuVasive, USA). During this period 20 patients were treated with an ILN for posttraumatic and congenital lower limb discrepancy. In 8 cases the tibia was lengthened while 12 patients underwent

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femoral lengthening. We utilized the trochanter tip entry point in all cases of antegrade femoral nailing. The entry point for retrograde femoral nailing was the intercondylar notch and the anterior spine of tibial plateau in cases of tibial nailing. We performed medullary reaming to a diameter of 2 mm larger than the intended nail diameter with standard reamer system (Synthes®). The PRECISE® nail was inserted until the level of the designated osteotomy site. Then, the osteotomy was performed utilizing either a Gigli saw or multiple drill holes and a chisel. As planned, a single osteotomy was performed as planned in all cases at the centre of rotation and angulation (CORA). Insertion of the nail with distal and proximal locking and bone grafting at the osteotomy site using autograft collected during reaming completed the procedure. Prior surgery and additionally to routine clinical work-up radiological studies including whole-leg standing x-rays were performed to identify the underlying deformity and quantify its extent. If necessary additional computer tomography and/or magnetic resonance imaging studies were obtained. Additional 4 patients underwent humeral lengthening. The senior author of this study performed pre-operative planning and conducted the surgical procedure including revision surgery in all cases. For this report, we performed a retrospective data analysis of patients who had required a revision surgery following ILN implantation. Collected data included radiological studies, surgery notes, and records from clinical follow-up documentation. The study was approved by the local ethics committee (Table 1).

Revision surgery

In 6 patients (30%) revision nailing was necessary. There were 4 male and 2 female patients. The Charleston Comorbidity Index (CCI) was 0 in all but 1 patient. In patient #6 a CCI of 4 was calculated (age 74 and stable peripheral vascular disease). 4 out of 6 cases had previous surgeries prior the lengthening procedure. Prior surgery laboratory measures and clinical examination was used to rule out possible infectious complications. Also, intraoperatively no sign of infection was observed. In cases of antegrade femoral and tibial nailing patients were in a supine position on a fracture table, while patients receiving a retrograde femoral nail were positioned supine on a standard table with 30° of knee flexion. Intraoperative fluoroscopy was used in all cases. The revision procedure included removal of the ILN and debridement at the primary osteotomy site in all cases. Following resection and reaming of the medullary canal, a recon nail was introduced using the same entry point and locked under fluoroscopy. Standard intramedullary locking nails were used in all cases. Additional autologous bone grafting was performed at the osteotomy site. Bone grafts involved reaming debris using a reamer-irrigator-aspirator (RIA, Synthes®) in 4 cases, while in the further 2 cases iliac crest autograft from the ipsilateral side was harvested (Table 2).

Postoperative treatment protocol

Following index surgery mobilization postoperatively included non-weight bearing until intended lengthening was achieved. Lengthening speed was set at 1 mm per day with each 0.5 mm in the morning and 0.5 mm in the afternoon starting at day 5 after surgery. After obtaining full extent of desired lengthening partial weight bearing with 15–20 kg was initiated. Full weight bearing was allowed after callus formation was observed radiologically. Intensive physiotherapy included passive and active mobilization starting from day 1 after surgery. Routine clinical and radiographic follow-up investigations were performed. After the revision procedure weight bearing as tolerated was initiated immediately postoperatively.

Statistical analysis

This study includes a descriptive analysis of a distinct patient cohort. Variables include categorical (sex, type of surgery, cause of deformity, type of deformity, affected bone, complication type, type of revision surgery) and numerical variables (age, extent of LLD, time interval between primary and revision surgery) were collected. Statistical calculations were performed using SPSS® software (Version 24, IBM, USA). Variables ware given as median and range in parenthesizes if not stated otherwise.

Results

We included 6 patients for the present clinical chart review. The median age of patients requiring revision surgery was 34.5 years (range 25–74 years) at the initial procedure. The indications for primary lengthening was LLD in all cases. In 3 cases (50%) LLD was posttraumatic, while in the other 3 cases congenital LLD was

Table 1
Patient demography at index surgery.

Patient #	Sex	Age at index surgery (y)	Leg length discrepancy (cm)	Localization of deformity	Etiology of deformity	Addtional deformity	Previous surgeries (#)	Nail insertion
1	M	35	3	Tibia	posttraumatic (open fracture)	valgus of distal tibia	2	antegrade
2	M	34	2.5	Femur	congential	–	0	antegrade
3	W	28	5.5	Femur	congential	–	multiple (>2)	antegrade
4	W	48	2.5	Femur	posttraumatic	internal malrotation and valgus	1	antegrade
5	M	25	4	Femur	posttraumatic	recurvation	1	retrograde
6	M	74	4.5	Tibia	congential	–	0	antegrade

Table 2
Patient demography at revision surgery.

Patient #	Cause for revision	Time to revision (m)	Age at revision surgery (y)	Type of revision implant	Complications of revision surgery
1	non-union	11	36	antegrade locking nail	–
2	nail-breakage	6	34	antegrade locking nail	–
3	non-union	11	29	antegrade locking nail	–
4	non-union, nail-rewinding	15	49	antegrade locking nail	–
5	non-union	12	26	retrograde locking nail	remaining recurvation
6	nail breakge	15	75	antegrade locking nail	claw toe deformity

present. Additional malalignment was seen in all posttraumatic cases and included valgus of the distal tibia, rotational and valgus malalignment of the femoral shaft, as well as distal femur recurvatum. Leg length discrepancy ranged from 2.5 cm to 5.5 cm (median 3.5 cm). At a median of 11.5 months (range 6–15 months) revision surgery with repeated nailing was performed. Indications for revision surgery included atrophic non-union with ambulatory pain in 4 cases (67%) and nail breakage in the two other ones. Following revision nailing, all patients in the study achieved complete bony healing and a satisfying clinical result with the desired extent of lengthening. In one case (pat. #5) recurvation malalignment at the initial fracture site (metaphyseal distal femur) of 15° remained. In another patient (pat. #6) tibial lengthening lead to claw toe formation, which was addressed by tenotomy. Expemplary cases are demonstrated in Figs. 1–3.

Discussion

Novel implant technology with externally controlled intramedullary lengthening devices have gained increasing interest over recent years and have revolutionized limb lengthening and deformity correction. Compared to previous techniques including external fixator-based correction ILN offer improved patient comfort and less soft tissue irritation during lengthening. On the other hand, complications during lengthening using ILNs usually require surgery while external fixators allow more

Fig. 1. Case #4 with image obtained 6 weeks postoperatively with intended lengthening of 2.5 cm (A), 2 months follow-up with beginning callus formation (B,C), at 5 months postoperatively rewinding of the telescopic nail was observed (D,E), image obtained 2 years after revision nailing with bony consolidation and lengthening goal achieved (F).

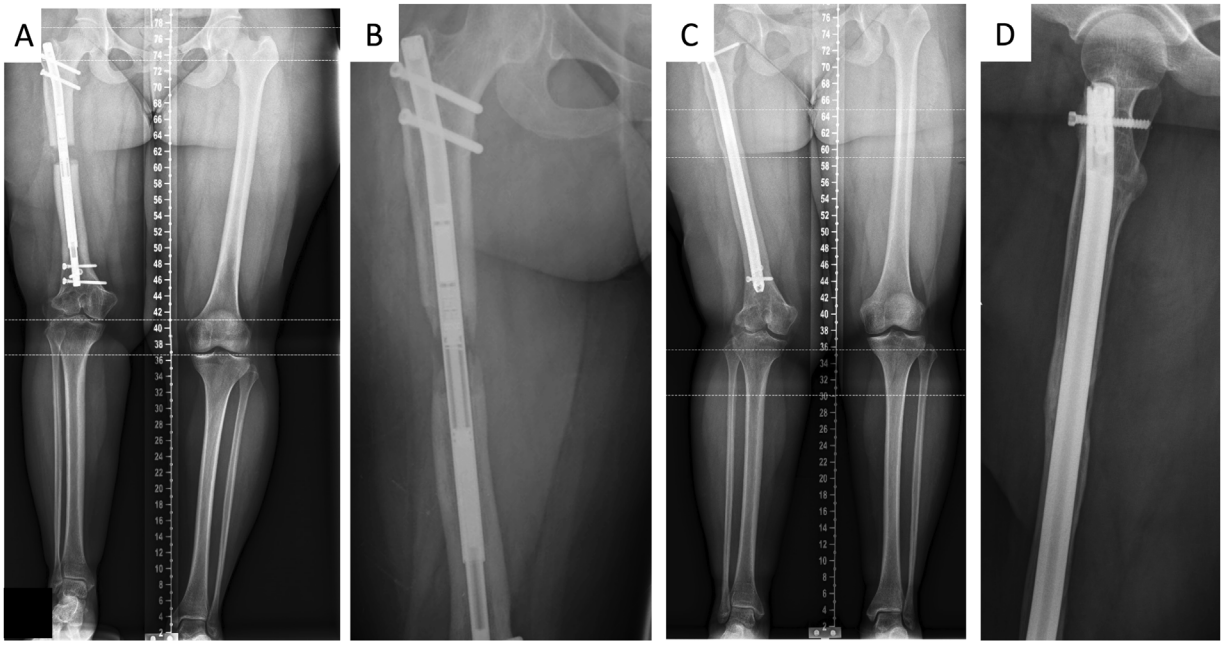

Fig. 2. Case #3, 2 months after implantation of the telescopic nail(A), 11 months follow-up with non-union (B), 3 years after revision surgery with completed union (C,D).

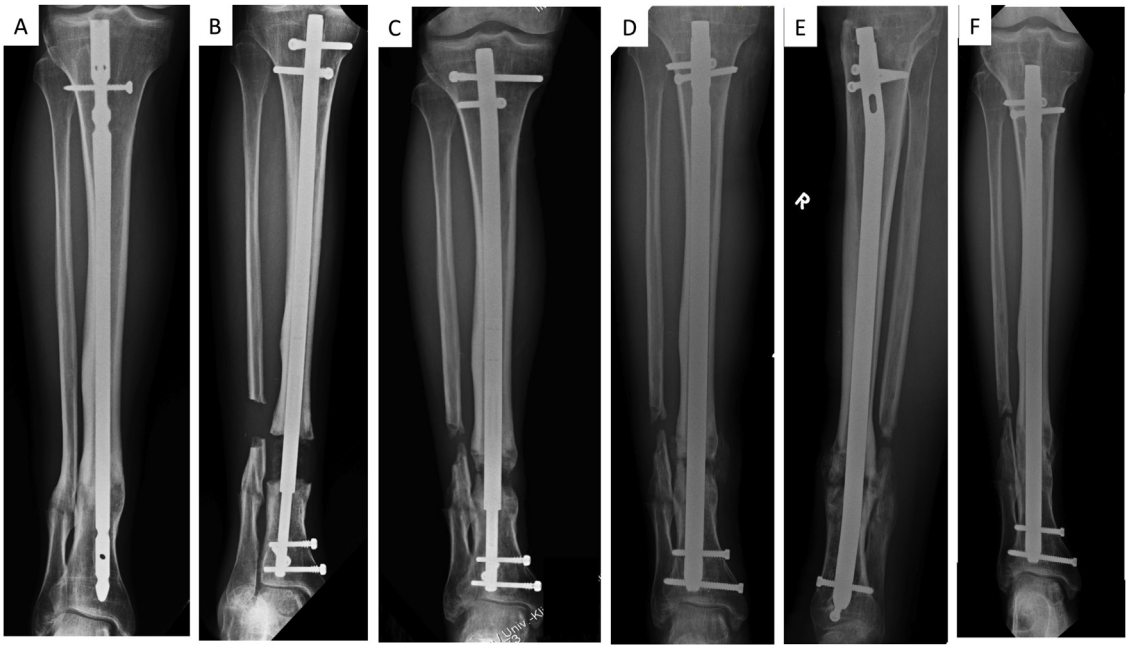

Fig. 3. Case #1 presented with a varus mal-aligned and 3 cm shortened tibia following a comminuted III° open fracture treated with a locking nail, preoperative image (A), 3 months postoperative with intended lengthening of 3 cm(B), non-union 8 months postoperatively (C), postoperative images after revision nailing (D,E), 2 years after revision surgery with nail exchange and autologous bone grafting (F).

readily manipulation and correction in an outpatient setting. To our knowledge, literature lacks reports on how to treat complications following implantation of ILNs. Therefore, we aimed to report our experience with secondary nailing following failed implantation of ILNs.

Our study implies that following failed implantation of intramedullary telescopic lengthening nails revision using a standard intramedullary locking nail with bone grafting provides satisfying results. Bone healing and the initial lengthening goal was achieved in all patients. Aside from persisting recurvation deformity in one case no surgery related complication was observed. In one case of tibial lengthening claw toe formation required further surgery. However, this complication was a consequence of the lengthening procedure per se rather than revision nailing.

Recently, many reports have proven the advantage of externally driven intramedullary telescopic nails for correction of LLD. Both femoral and tibial lengthening was reached using this device in congenital as well as in posttraumatic cases.

The main reason for revision surgery was non-healing at the lengthening site with associated pain in our patients. Our non-healing rate was high with 20% of the overall patients. Similar rates of non-union were reported by Shabtai et al. with 4 out of 21 cases [12]. They reported a comparable rate of revision surgeries with 33% [12]. Hammouda et al. performed multiple drill holes at the osteotomy site prior reaming allowing reaming debris to allocate around the osteotomy site [16]. This technique of autologous bone grafting might be favourable in terms of consolidation rates. In their study the authors reported no case of non-union while in 2 out of 17 cases premature consolidation was observed [16]. Nail breakage is a known nonetheless infrequent observed complication following implantation of telescopic ILNs [3,1011].

An important question to raise in revision surgery is timing of secondary procedures. Except for case #2 with only 2 months interval between index and secondary surgery, all revision surgeries were performed around 1 year (between 11 and 15 months) after initial surgery. Based on our experience and satisfying results, we suggest revision nailing within this time frame in cases of non-union. If revised too early, the chance of delayed union might be skipped potentially. In cases of nail breakage, revision surgery is necessary as soon as breakage is obvious. A recent study by Horn et al. reported surgery-necessitating complications in 8 out of 50 cases (16%) with no further information on timing of revision surgery [2]. Also in other studies no information regarding this issue was available.

In our patient collective, many patients underwent multiple surgeries prior implantation of the lengthening nail. This potentially increases the complications risk such as non-union due to compromised bone vasculature and surrounding soft tissue [9,12,14,15]. Despite these obstacles encountered following multiple previous surgeries our described method of revision nailing and autologous bone grafting lead to union in all cases.

One the main contributors to risk of non-union is bone quality [13]. Patients included in this study were in general young and healthy suggestive of adequate bone quality. Most patients underwent previous revision surgeries, which might have caused impaired local bone structure and increased the risk of non-union.

With increasing reports showing favourable results of telescopic intramedullary nailing no concise study is currently available discussing the treatment of complications associated with this technique. To our knowledge, this is the first study to provide a series of patients treated for ILN-associated complications. It's retrospective and descriptive character represents the major limitation of this study.

Conclusion

Repeated nailing with bone grafting using standard intramedullary locking nails presents a practical treatment strategy in cases of failed lengthening using telescopic intramedullary lengthening nails. Indications for ILN-assisted lengthening need to be considered carefully especially in patients with a history of multiple previous surgeries of the targeted bone.

Declaration of Competing Interest

None.

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