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ORIGINAL STUDY

Promises and difficulties with the use of femoral intra-medullary lengthening nails to treat limb length discrepancies

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Limb lengthening using external fixation may be associated with problems such as pin-track infections, poor patient acceptance, muscle transfixation, secondary axial deformity and re-fractures. Intramedullary lengthening nails have been designed to address these issues. We present our results for femoral limb lengthening in adults managed by intramedullary lengthening nails.

A retrospective review was undertaken for 8 femoral lengthening procedures performed in adults using intra-medullary lengthening nails over a three-year period. The average age of our patients was 34 years ; the average duration of follow-up was 26.5 months (range : 8 to 40 months). An Albizzia nail was used in 5 procedures, an Intra-medullary Skeletal Kinetic Distractor (ISKD nail) in 3 procedures.

Target lengthening was achieved in 6 out of 8 femurs with an average of 38.77 mm (range : 0 to 70 mm) length gained. The distraction index (length gained per day) was 0.58 on average (range : 0-1.25) and the consolidation index average was 50.39 (range : 0-79) days/cm.

Premature consolidation was noted in 4 cases, runaway acute lengthening in one patient ; prominent metalwork – noted in 4 patients – and a bent nail were frequent obstacles and meant multiple visits to theatre.

Femoral lengthening with an intramedullary lengthening nail is a reasonable alternative to external fixators, thereby avoiding problems associated with callotasis using external fixation methods. It is however, important to counsel patients regarding possibilities of significant obstacles including failure and multiple visits to theatre during the process.

Keywords : femoral lengthening ; complications ; intramedullary nails ; external fixator.

INTRODUCTION

Distraction osteogenesis is a well established method of treatment to correct limb length discrepancies. Limb lengthening can be carried out with ring fixators, intramedullary lengthening nails or combination nail and mono-rail external fixation (*1-3,9,15-18,20,21,23-25*).

Traditionally, external fixators have been used to induce callus distraction, however they are associated with numerous complications. Soft tissue transfixation by the pins and wires can cause

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muscle contractures, joint stiffness, pain and pin track infection. In addition, lengthening of the limb by the external fixator is associated with possible neurovascular complications, recurrent deformity, re-fracture of the regenerate bone and stress fractures secondary to osteoporosis. Also rehabilitation is delayed because of the long period of presence of the external fixators (*4,5,11,16-19,21,22*).

The combination of the intramedullary nail and unilateral external fixator which is only applied during the distraction period reduces the time of the external fixation. However there is theoretically a potential risk of minor pin track infections, threatening the entire lengthening process. Infection with intramedullary nailing after previous external fixation of femoral fractures is well known (*2,18,20,21*).

Intramedullary motorised lengthening device with a subcutaneous receiver was first developed by Betz and Baumgart *et al* and was successfully implanted in patients for distraction osteogenesis and limb lengthening (*2*). Guichet *et al* designed the first mechanically activated lengthening device (Albizzia nails). With these intramedullary lengthening nails, the patient's limb movements generate the mechanical forces required to achieve distraction osteogenesis over the nail (*8*). Hankemeier *et al* have reported successful outcomes with the use of the intramedullary skeletal kinetic distractor for intramedullary lengthening (*9*).

We report our experience with the use of the intramedullary femoral lengthening nail in seven patients (8 femurs).

MATERIALS AND METHODS

We carried out a retrospective review of seven consecutive adult patients (8 femurs), who had undergone femoral lengthening using intramedullary lengthening nails between Jan 2003 and Nov 2007. Patients with previous bone infection, very narrow medullary canals or severe deformities were excluded from the study.

There were six male patients and the mean age was 34.25 years (range : 20-53). In six patients the limb length discrepancy was secondary to trauma. The mean leg length discrepancy was 35 mm (range : 20-60 mm). Except in one patient (# 5) who had shortening with 20° of varus angulation and 20° external rotation deformity, the rest had only shortening preoperatively. One patient had congenital short stature (2 femurs). This patient had a significant body image issue and the lengthening was carried out in consultation with and following a detailed psychological workup (Fig. 1a,b,c). All the patients had good range of knee and hip movements pre-operatively.

Five patients underwent femoral lengthening with Albizzia nails (University Center (CHU) of Dijon, France) and three with ISKD nails (Orthofix, Valley, Germany).

All procedures were carried out under general anaesthesia with image intensifier control by the senior author (RAW) and nails were inserted in antegrade fashion into the femur. In our unit the senior author used both the Albizzia and ISKD nails for femoral lengthening.

Intraoperatively, open osteotomy was performed through the lateral stab incision and over the guide wire. The rotation was controlled by placing two parallel 3 mm Krischner wires in proximal and distal fragments. For femoral osteotomy, the multiple drill holes technique was used and transverse drillings were made under image intensifier control.

Distraction was started from the first follow-up appointment, which was five days post-operatively. Patients were allowed to mobilize touch weight bearing using crutches / frame as per comfort. Their discharge from the ward was guided by their safe mobilization and demonstration to understanding the distraction mechanism. In cases where there was any doubt about the distraction initially, a radiograph was used to confirm distraction. The patients were followed up in outpatient's clinic after discharge.

The mean duration of the follow-up was 24 months (range : 8-42 months).

RESULTS

Target lengthening was achieved in six out of eight cases. The angulation and external rotation was corrected with an osteotomy in case 5. The average gain in length achieved was 38.4 mm (range : 0-70 mm).

The mean distraction index (Distraction index = length gained divided by days taken to distract) was 0.58 mm/day (range : 0-1.25) and the mean consolidation index 50.39 (range : 0-79) days/cm. There was a satisfactory mechanical axis of the lower extremity in all patients who achieved the target lengthening.

The outcomes evaluated were the obstacles encountered during the femoral lengthening

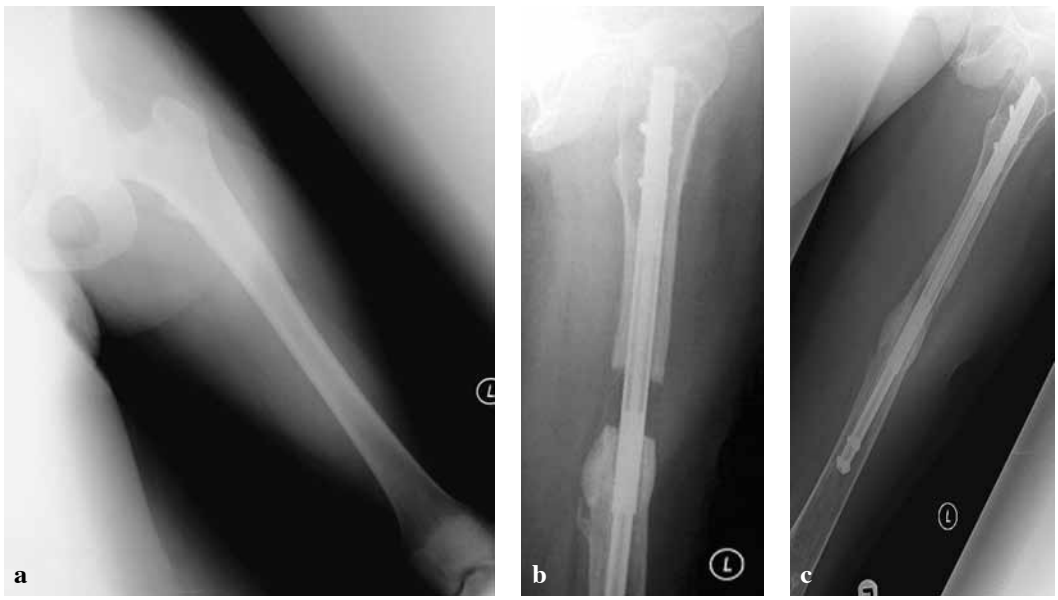

Fig. 1. — a. Left femur of short stature patient ; b. Femoral lengthening with nail in situ ; c. Consolidation and achievement of desired lengthening.

procedure and complications leading to increased hospital stay.

Premature consolidation was noted in 4 cases, runaway with acute lengthening in one patient ; prominent metalwork as seen in 4 patients and a bent nail were frequent obstacles and meant multiple visits to theatre.

The average hospital stay was 11.6 days (range : 4 to12 days). The preoperative knee and hip function was regained in all patients. The extensor mechanism was not impaired, and there was no stiffness of the knee. All patients had a normal gait at final follow-up.

One patient (case 2) had premature consolidation at the corticotomy site and had to undergo redo corticotomy. Two patients (case 1 & 7a) had difficulty to distract the nail, needing a further visit to theatre for manipulation under anaesthesia.

Complications were classified according to a modification of the system proposed by Paley (*18*) ; grade 1 is defined as problems (difficulties that arise during treatment which ISKD nails can be fully resolved non-operatively) ; grade 2, as obstacles (difficulties that arise during treatment which can be fully resolved operatively) ; and grade 3, as sequelae (temporary or permanent difficulties that remain after removal of the external fixator). Grade-3 complications are subdivided into minor or major sequelae according to their clinical importance.

Another patient (case 6) had premature consolidation at the corticotomy site for which he declined any further treatment in the form of manipulation or corticotomy. This meant that we failed to achieve the target length and hence consider this as a failure of the procedure. Another patient had a dramatic acute runway lengthening of the nail by five centimetres overnight postoperatively following the ISKD nailing and the patient developed non-union and had to undergo exchange nailing and autologous bone grafting.

Other complications were prominent metalwork in four patients and further four patients had muscle hernia, bent nail and failure to remove the hardware (Fig. 2a,b,c,d). There were no infections in these patients.

DISCUSSION

Limb lengthening with ring fixators is associated with complications that include muscle contractures,

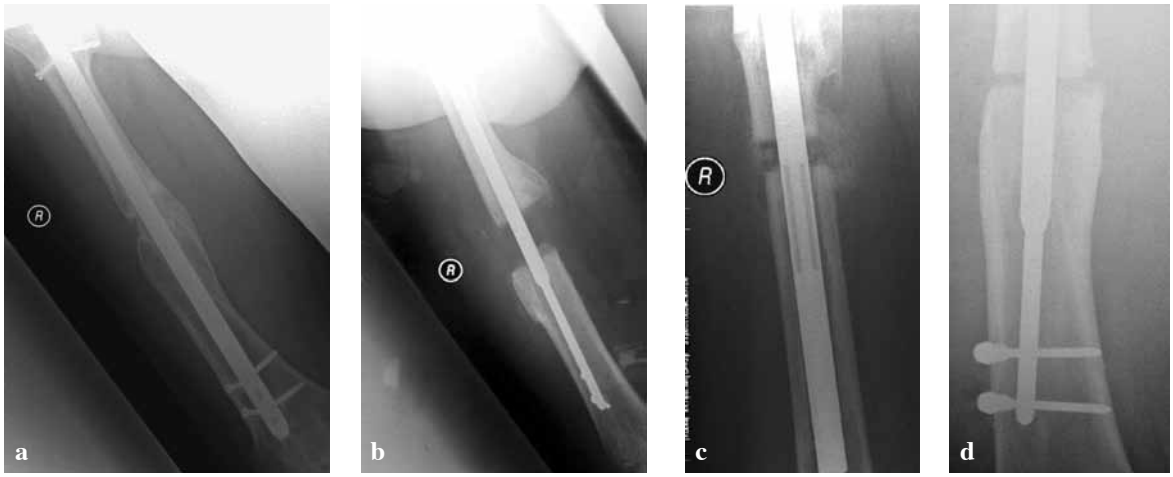

Fig. 2. — a. Broken Screws ; b. Acute runaway of the nail (5 cm) ; c. Premature consolidation before desired lengthening achieved ; d. Failure to achieve lengthening.

joint dislocation, axial deviation, neurologic injury, vascular injury, premature consolidation, delayed union, nonunion, pin site problems, and hardware failure. Late complications are loss of length, late bowing, and re-fracture.

Joint stiffness may also be a permanent residual complication. Pain and difficulty sleeping are other problems that arise during limb lengthening, especially in the more extensive cases (*4,5,11,19,22,25*).

Noonan *et al* (*16*) described the use of a monorail system for distraction osteogenesis, with which they achieved the desired lengthening in femurs and tibias, but the cost, treatment time and complications were all increased.

The methods of limb lengthening with combination of the intra-medullary nail and external fixators and a fully implantable motorized intramedullary nail have been successfully used to reduce the complications rates compared with Ilizarov and a monorail system (*2,18,20,21*).

In limb lengthening with a motorized nail in comparison to external fixators, the advantages are simple handling, the programmable motor with exact control, early weight bearing, faster rehabilitation, and excellent functional results already present during the consolidation phase. Potential advantages of intramedullary lengthening devices include the reduced risk of contractures and infections, better maintenance of axis correction, a lower rate of refractures, reduction of pain resulting from the elimination of soft tissue transfixation, and an earlier return to daily activities (*15,24,25*).

The Albizzia femoral lengthening intramedullary nail consists of two telescoping tubes- threaded outer tube and inner rod-connected by a double opposed ratchet mechanism. Rotation of the inner tube by 20° in one direction causes the ratchet mechanisms to be unscrewed and the nail to be lengthened. Rotation in the opposite direction resets the ratchets and the rotation at a neutral position, maintaining the gain that was obtained (*7*).

ISKD is designed to lengthen under physiologically tolerable movements. The ISKD lengthens as small oscillations between telescoping sections are converted to one-way distractions. As the patients rotationally oscillate the limb either manually or during walking, the devise gradually distracts. The rate of distraction is monitored using an external hand-held sensing device (*3*).

The advantage of the limb lengthening using the intramedullary nails is that it allows gradual lengthening with bone healing which can be safely achieved (*6,7,8*). Other advantages include reduced risk of contractures and infection, prophylaxis of axis deviation and re-fractures, reduction of pain due to the elimination of the soft tissue transfixation and earlier return to daily activities (*3,6,7,9,10,14, 15,23*).

Table I. — Clinical details and results

Pat No	Age (yrs)	Sex	Indication	Deformity	Type of nail	Hospital Stay (days)	Lengthening Planned (mm)	Lengthening achieved (mm)	Distraction Index mm/day	Consolidation index (Days/cm)	Additional procedures	Total Operations	Follow-up Duration (months)	Final mechanical axis and outcome
1	38	M	Trauma	Shortening	ISKD	9	35	0	0	0	1.Failure to distract 2.Premature consolidation	3	8	Unsatisfactory
2	46	M	Trauma	Shortening	Albizzia	4	20	20	0.34	158 (79)	1.Corticotomy consolidated 2.Prominent locking screws	3	12	Satisfactory
3	44	M	Trauma	Shortening	Albizzia	11	20	19	0.90	109 (57.36)	1.Symptomatic locking bolt 2.Symptomatic metalwork(nail)	3	42	Satisfactory
4	25	F	Trauma	Shortening	ISKD	7	35	35	1.25	200 (74.28)	1. Removal of nail	2	17	Satisfactory
5	53	M	Trauma	Shortening & 20° varus & 20° external rotation	ISKD	5	60	60	0.63	180 (30)	1.Runaway by 5cm overnight 2 Bent nail 3.Non-union 4.Superficial wound infection	3	36	Satisfactory
6	27	M	Trauma	Shortening	Albizzia	4	40	0	0	0	1.Early consolidation	1	10	Unsatisfactory Patient refused further operations
7a	21	M	Congenital (short femur)	Shortening	Albizzia	12	70	68	0.75	210 (32.30)	1.Failure to distract 2.Muscle hernia 3.Metalwork problem (bent nail)	3	33	Satisfactory
7b	21	M	Congenital (short femur)	Shortening	Albizzia	9	70	70	0.81	200 (29.4)	1.Metalwork problem(nail breakage)	2	34	Satisfactory

Kenaway *et al* (*13*) & Hankemeier *et al* (*9*) conclude from their studies, that distraction problems with intramedullary skeletal kinetic distractor are mostly due to dysfunction within the ratcheting mechanism, which may be related to the diameter of the nail. New designs for mechanically activated nails with a better control mechanism for the distraction rate are required.

Baumgart *et al* (*2*) reported on 12 cases of successful femoral lengthenings using motorized intramedullary lengthening nails and concluded that this method has rate and rhythm control with better bone formation, but requires highly sophisticated planning and insertion technique.

However, there are complications associated with these devices which include ; hardware failure, failure or incomplete lengthening, further surgical procedures and less control over the lengthening process (*3,6-9,23*). Details of the outcomes and complications from the other studies on femoral lengthening nails are shown in Table I.

In our study most theoretical advantages of the lengthening nail were achieved, like avoiding axis deviation, avoidance of soft-tissue impalement, recurrent pin infections, patient acceptance of device, early rehabilitation / joint movements and no re-fractures. We were able to achieve the targeted lengthening with satisfactory outcome in 6 out of 8 patients (Fig. 1a,b,c).

We experienced frequent obstacles with the failure of the nail to function and subsequently leading to multiple visits of the patients to theatre. There was an average of 1.75 significant complications per patient, with an average of 2.87 theatre episodes per patient.

Total duration of hospital stay was not necessarily shorter than with patients having frames. Also we encountered the following complications : superficial infections, acute runaway of the nail, premature consolidation at the corticotomy site, non-union and hardware problems.

We feel that the problems that were associated with distraction of the nails were mostly due to the failure within the nail ratcheting mechanism. New lengthening intra medullary nail designs with a better control mechanism for the distraction rate are required.

Femoral lengthening with the intramedullary lengthening nail is a reasonable alternative to external fixators, thereby avoiding problems associated with callotasis using external fixation methods. It is however, important to counsel patients regarding possibilities of significant obstacles including failure and multiple visits to theatre during the process.

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