Acta Orthop. Belg., 2009, **75**, 200-208

ORIGINAL STUDY

Telescoping versus non-telescoping rods in the treatment of osteogenesis imperfecta

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A retrospective study was undertaken to evaluate and compare the results of telescoping (group I) versus non telescoping rods (group II) in the treatment of osteogenesis imperfecta. Thirty-three lower limb segments in ten patients were studied (14 segments in group I and 19 segments in group II). The surgical techniques of Sofield and Miller (1959) and Lang-Stevenson and Sharrard (1984) for rod insertion were used. All cases were assessed clinically regarding mobility status, growth and limb-length, refracture, and infection. They were also assessed radiologically regarding rod migration, bone outgrowing the rod, incorrect T-piece placement, breakage and bending of rods. The average duration of follow-up was 86.2 months (range : 6 to 8 years). Mobility status and bone growth were better in group I than in group II patients. The overall implant related complication rate was 28.6% in group I in comparison to 68.4% in group II. Rod migration was twice more common in group II than in group I. Bone outgrowing the rod and breakage of rods with fracture was seen in group II only. The three-year survival rate for telescoping rods was 92.9% in contrast to 68.4% for non telescoping rods. The reoperation rate was 7.2% in group I and 31.6% in group II. From this comparative study it was clear that the results were significantly better after Sheffield rods with regard to mobility status, longevity of the rod, and the frequency of complications requiring reoperations. Also most of the complications were related to the technique of rod insertion and the type of rod.

Keywords : osteogenesis imperfecta ; telescoping rods ; Rush pins.

INTRODUCTION

Children with osteogenesis imperfecta are well known to sustain multiple, recurrent, and pathological fractures. These fractures may not only decrease their functional ability, but also decrease their quality of life as a result of associated pain (2). Operative treatment is indicated when multiple fractures or progressive deformities preclude orthosis use and prevent ambulation. Until a systemic treatment is proven clinically effective, the problem of frequent fractures and deformities in osteogenesis imperfecta must be treated by supporting the axial and appendicular skeleton with bracing and

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No benefits or funds were received in support of this study

intramedullary rodding (1). The use of multiple osteotomies with intramedullary rodding is a well established treatment method for this problem as it corrects deformity, improves function, and prevents future fractures of the involved extremity. Although controversy still exists regarding the use of telescoping rods (TR) versus non telescoping rods (NTR), all authors agree that both methods improve the functional ability and decrease the morbidity associated with osteogenesis imperfecta, with a measurable improvement with elongating rods more than with non–elongating ones. The Baily-Dubow rod was designed to overcome some of the complications of nonextensible rods and the Sheffield rod was designed to overcome some of the complications of the Baily-Dubow rod (11,15,18).

The purpose of this retrospective study was to evaluate the results of telescoping and non telescoping intramedullary rodding of the bones of the lower extremities in children and adolescents with osteogenesis imperfecta.

PATIENTS AND METHODS

This retrospective study includes ten patients with osteogenesis imperfecta treated with intramedullary rods for recurrent fractures and/or deformities in the lower extremities, at the Mansoura University Hospital. Five patients were treated using Sheffield elongating rods (group I) and the other five using non-elongating Rush pins (group II). A total of 33 lower limb segments were treated, using 14 telescoping Sheffield rods (9 femoral and 5 tibial) and 19 non-telescoping rods (11 femoral and 2 tibial) (table I).

Six bony segments (4 femora and 2 tibia) were treated secondarily with telescoping rods as a revision of primary Rush pins. In this study the Sheffield telescoping rod, which is a modification of the Bailey–Dubow rod with a non detachable T-piece was used as a prospective study in group I compared to non elongated Rush pins used in group II. The mean age at primary surgery was 4.8 years for group I and 5.2 years for group II.

Pre-operative planning

The technique of preoperative measurement of the length and thickness of the telescoping rod described by Mulpuri and Joseph (12) was used as we did not have the whole series of rods in stock as recommended by Lang-Stevenson and Sharrard (8). Only two sizes were provided by the company according to the pre-operative planning. The ideal length chosen was usually that measured on the lateral and not on the anteroposterior radiographs because of the associated flexion contractures and sometimes two-plane-deformities. On the lateral projection the bone was cut at different levels, removing wedges with their bases on the convex side. Then the bone segments were connected together, correcting the deformity and allowing assessment of the actual rod length. The rod thickness was equal to the narrowest portion of the medullary canal.

Table I. — Rod type in relation to lower limb segments

Type of rod	Bone segment	Number of segments
Sheffield rod (n = 14)	Femur (n = 9)	Primary (n = 5) Re-rodding (n = 4)
	Tibia (n = 5)	Primary (n = 4) Re-rodding (n = 2)
Rush pin (n = 19)	Femur (n = 11)	Primary (n = 8) Re-rodding (n = 3)
	Tibia (n = 8)	Primary (n = 6) Re-rodding (n = 2)

Surgical technique

The surgical technique for rod insertion was that described by Sofield and Miller (16) and Lang-Stevenson and Sharrard (8) with some modifications for telescoping rods. Antegrade or retrograde techniques for non-telescoping rod insertion were used. Regarding the telescoping rod insertion in both femoral and tibial segments, the outer sheath was placed proximally and the obturator distally. During femoral rodding the proximal T-piece was buried under the gluteal muscle insertion just outside the greater trochanter or within 0.5 cm of the tip of the trochanter. All efforts were made to place the rod in the medullary cavity in a central position and to place the T-piece into the articular half of the distal femoral and proximal tibial epiphysis (figs 1 & 2). Similarly during tibial rodding the distal T-piece was placed intra-articularly through a trans-deltoid ankle approach without the need to bury it into the distal tibial epiphysis to facilitate rod exchange (fig 3). In one patient an Ilizarov ring fixator was used as a preliminary surgical step to give some soft tissue lengthening and to decrease the amount of bone shortening (fig 4).

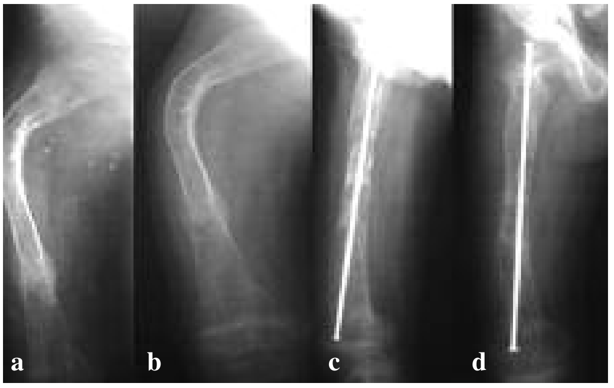

Fig. 1. — Osteogenesis Imperfecta with right femoral deformity.
a,b. Pre-operative radiograph showing the deformity ; c,d. Post-operative radiograph showing the corrected deformity with telescoping rod.

Fig. 2. — Osteogenesis Imperfecta with bilateral femoral deformities.
a. Pre-operative radiograph showing the severity of the deformity ; b,c,d. Post-operative radiograph showing Rush pin with bone outgrowing the rod for the right femur, and telescoping rod for the left femur, with epiphyseal to epiphyseal support and the difference in limb-length measurement.

Post-operative management

Post operative plaster immobilisation was maintained for 6 weeks in all patients except if there was a delay in union at any osteotomy site, in that case 2 to 4 weeks immobilisation was added (4 femoral and 9 tibial segments). Ambulation with the aid of wheelchair, crutches or walker was encouraged once the osteotomies had united according to each patient's special situation. No external splintage or appliance was used once the osteotomies had completely united.

Assessment

All patients were followed for an average duration of 86.2 months (range : 6 to 8 years). Clinical and radiological assessments were done for all lower limb segments in both groups. Clinical assessment included patient age (at the time of primary surgery, revision surgery, and at final follow-up), type of rod, mobility status, limb-length, and incidence of infection. Regarding mobility status, each child was allocated to one of the categories proposed by Hoffer and Bullock (5), preoperatively and at final follow-up . Limb length was measured clinically from the anterior superior iliac spine down to the adductor tubercle (femoral length) and from the adductor tubercle to the tip of the medial malleolus (tibial length) as radiological projection errors were commonly encountered due to joint contractures and deformity.

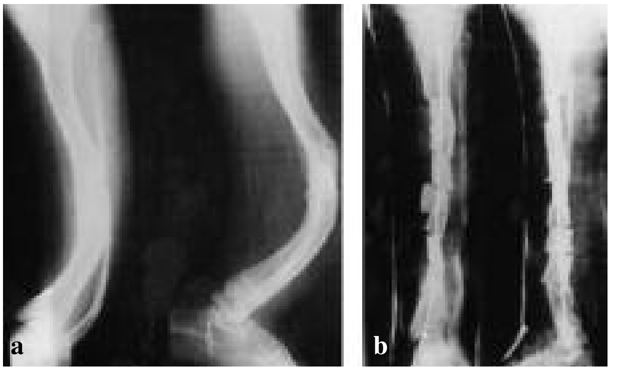

Fig. 3. — Osteogenesis imperfecta with bilateral tibial and fibular deformities.
a. Pro-operative radiograph with AP and lateral views ; b. Immediate post-operative radiograph showing multiple osteotomies and intra-articular position of the T-piece through the trans-medial collateral ligament (trans-deltoid) approach of the ankle.

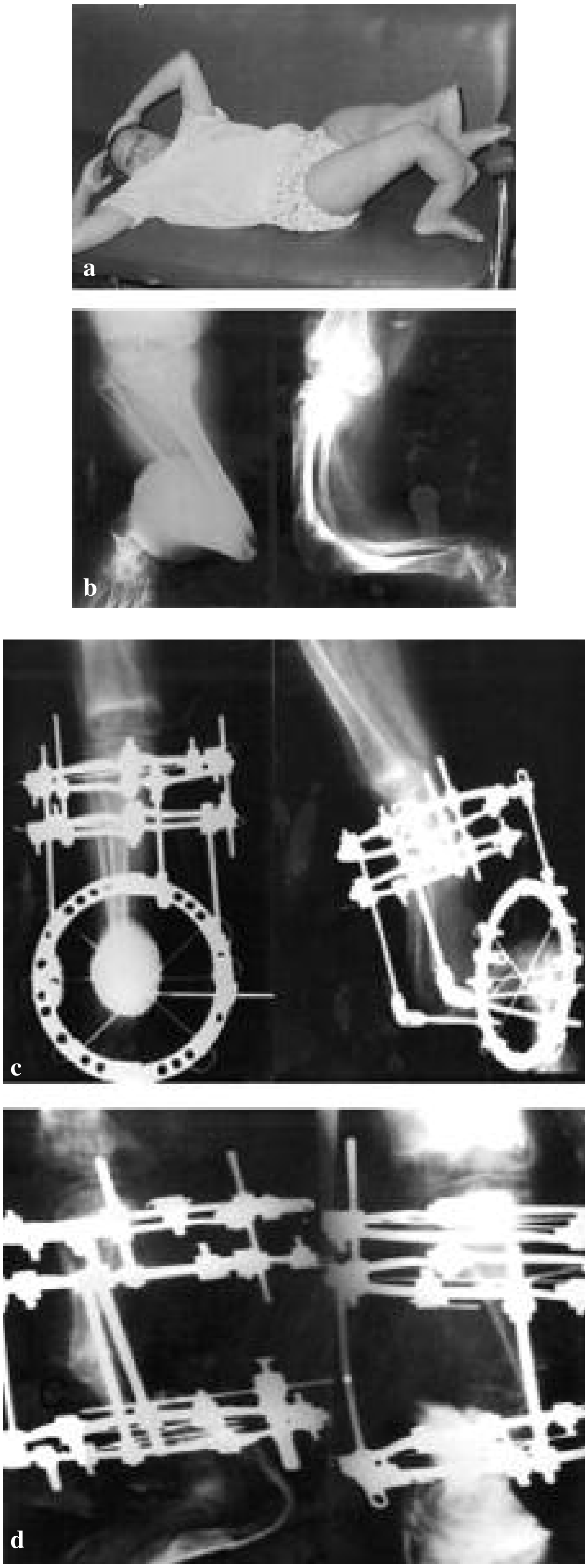

Fig. 4. — Osteogenesis Imperfecta showing bilateral severe tibial deformities.
a. Pre-operative photograph showing the degree of deformity, and penetration of the skin of the left side ; b. Pre-operative radiograph showing the degree of deformity ; c. Post-operative radiograph after osteotomy, shortening, and Ilizarov frame application over the right leg, showing the two rings at different angles to each others ; d. Follow-up radiograph after full correction showing parallel rings ; e. Post-operative radiograph after intramedullary Rush pin with pop cast for the right leg ; f. Final follow up radiograph after full healing on the right side ; g,h. Final follow up radiograph after full healing on the left side following the same technique used for the right side.

Table II. — Mobility status

Status	Telescoping rod		Non-telescoping rod	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Non-walker or wheelchair-bound	2	1	2	1
Household walker	2	1	3	2
Community walker	1	2	0	2
Walks unaided	0	1	0	0

Radiological assessment included accuracy of rod placement, failed expansion, rod migration, bending and breakage of rods, disengagement, refracture, and rod survival.

Statistical analysis

The data of both groups were analysed using Student's T-test and Mann-Whitney U Tests for comparison between two groups. For comparing proportions the X^2 Test was used. A probability value of 0.05 or less was considered significant for all the above comparisons.

RESULTS

Mobility status

In group I, four patients out of five progressed in their mobility status : one from wheelchair-bound to household ambulator, two from household to community and one from community to an independent ambulator. In group II, three patients out of five progressed in their mobility status : one from wheelchair-bound to household and two from household to community ambulators. There was no statistically significant relationship between the type of rodding and the improvement in mobility status (table II).

Growth

Three patients (with two femora and one tibia) had an elongating rod in a limb segment on one side and a non elongating rod on the contra-lateral side (fig 2). In these patients measurements indicated that the limb segment treated with a telescoping rod showed more growth increase than the contra-lateral segment treated with a non-telescoping rod, although the telescoping rods were inserted later (range : 6 weeks to 6 months). These findings were found to be statistically significant (table III).

Complications

The total frequency of implant related complications was 28.6% (4 limb segments out of 14 in both primary rodding and secondary rerodding) in the telescoping rod group in contrast to 68.4% (13 limb segments out of 19 in both primary rodding and secondary rerodding) in the non-telescoping rod group (table IV). This relationship was found to be statistically significant. Rod migration was twice more frequent in the non-telescoping rod than in the telescoping rod group (table IV). Bone outgrowing the rod was only a problem related to non-telescoping rods and was found in 5 out of 19 bone segments (fig 5a-c). A broken rod with bone fracture was reported in one limb segment, and refracture of the unsupported distal femoral bone segment which outgrows the distal end of the rod was reported in another limb segment in the non-telescoping rod group. Bending of a rod without bone fracture was reported in one limb segment in both the telescoping and the non-telescoping rod group. Rod migration without disengagement of the sheath and the

Table III. — Length of limb segment in relation to the type of rod

Bone	Telescoping rod	Non-telescoping rod	Difference
Femur	30.5 cm	29.0 cm	1.5 cm
Femur	37.0 cm	35.0 cm	2.0 cm
Tibia	28.5 cm	28.0 cm	0.5 cm

Table IV. — Complications

Complications	Telescoping rod (n = 14)				Non–telescoping rod (n = 19)			
	Primary (n = 8)		Re–rodding (n = 6)		Primary (n = 14)		Re–rodding (n = 5)	
	No.	%	No.	%	No.	%	No.	%
Rod migration	2	25	–	–	3	21.4	1	20
Bone outgrowing the rod	–	–	–	–	4	28.6	1	20
Incorrect T–piece placement	1	12.5	–	–	NA		NA	–
Broken rod with fracture	–	–	–	–	1	7.1	–	–
Bent rod without fracture	1	12.5	–	–	1	7.1	–	–
Refracture	–	–	–	–	1	7.1	–	–
Infection	–	–	–	–	–	–	1	20
Total	4	50	–	–	10	71.3	3	20

Table V. — Rod migration in relation to primary rod position

Rod position	Telescoping rod		Total No. (%)	Non–telescoping rod		Total No. (%)
	Migration	No migration		Migration	No migration	
	No. (%)	No. (%)		No. (%)	No. (%)	
Central placement	0 (0%)	12 (100%)	12 (100%)	0 (0%)	15 (100%)	15 (100%)
Eccentric/oblique placement	1 (100%)	0 (0%)	1 (100%)	4 (100%)	0 (0%)	4 (100%)
Articular half of epiphysis	0 (0%)	0 (0%)	0 (0%)	Not applicable	–	–
Metaphyseal half of epiphysis	1 (100%)	0 (0%)	1 (100%)	Not applicable	–	–
Total	2 (14.3%)	12 (85.7%)	14 (100%)	4 (21.1%)	15 (78.9%)	19 (100%)

obturator parts of the telescoping rod was reported in two bone segments in the telescoping rod group. The rod migrated from the greater trochanter proximally, which resulted in migration of the distal T-piece from the distal femoral epiphysis into the metaphysis of the distal femur (fig 5d). In the non-telescoping rod group, rod migration through the bony cortex was reported in 4 bone segments (fig 5a, b). Rod migration, associated with eccentric or oblique placement of the rod into the medullary canal was found in one femoral segment in the telescoping rod group in contrast to three femoral and one tibial segment in the non-telescoping group (table V). The three-year survival rate of telescoping rods was 92.9% in contrast to 68.4% for non-telescoping rods. The reoperation rate was 7.2% in the telescoping rod group in comparison to 31.6% in the non-telescoping rod group (table VI).

DISCUSSION

Bowing of long bones in patients with osteogenesis imperfecta with or without fracture is the main concern of orthopaedic surgeons as a permanent cure of the disease still remains elusive. The indications for surgery include long bone deformities prohibiting bracing and ambulation, and significant remaining linear growth. Based on the information available in the literature and the results of this study, intramedullary rodding of long bones in osteogenesis imperfecta greatly improves the quality of life (*1-4,8,11,15-19*).

Table VI. — Frequency of three years rod survival and reoperation

Type of rod	Survival of the rod No. (%)	Reoperation rate No. (%)	Total No. (%)
Telescoping rod	13 (92.9%)	1 (7.2%)	14 (100%)
Non-telescoping rod	13 (68.4%)	6 (31.6%)	19 (100%)

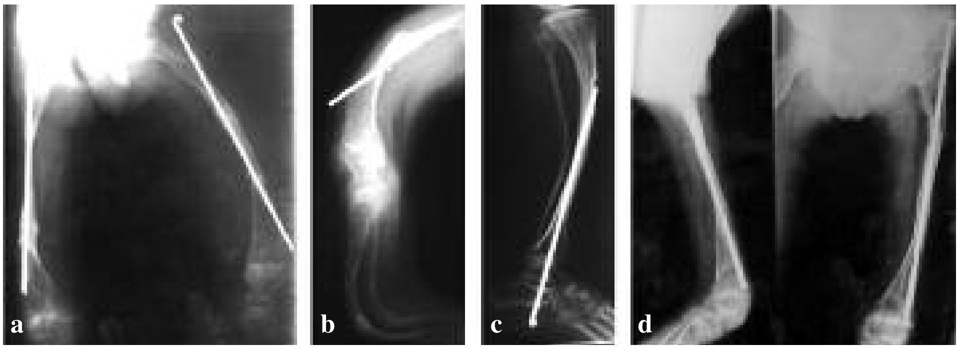

Fig. 5. — Complications.
a,b,c. Bone outgrows the Rush pin with penetration of the cortex ; d. Proximal migration of the elongating rod through the greater trochanter with epiphyseal-metaphyseal position of the T-piece.

In this study the mobility status improved by at least one class in most of the patients. No child walking preoperatively regressed to a non-ambulatory status. Nicholas and James (*13*) found that nine patients, treated with expandable intramedullary rods and who were non-ambulatory preoperatively, were able to walk after surgery.

Porate *et al* (*14*) reported that gait capacity improved in eight patients, regressed in three, and remained unchanged in nine. Luhmann *et al* (*9*) reporting on their 20 years experience in treating osteogenesis imperfecta with extensible intramedullary rods, found that four out of twelve patients who had never walked preoperatively were able to ambulate with varying levels of assistance.

Sofield and Miller (*16*) reported no disturbance in growth when a smooth medullary nail penetrated the physis. Harrison and Rankin (*4*) and Luhmann *et al* (*9*) reported no growth disturbance after using Bailey-Dubow rods. In this study, no growth disturbance was reported with the trans-physeal rod placement. However, an unexplained increase in growth was found in three cases treated with a telescoping rod on one side and a non-telescoping rod on the other side, based on the premise that leg length was equal at the beginning of surgical treatment although the timing of surgery was different with a range from 6 weeks to 6 months. Luhmann *et al* (*9*) stated that detection of growth disturbances in cases of osteogenesis imperfecta can be difficult, because not only can the individual bone be abnormally small and severely malaligned, but it also may be further shortened during the rodding procedure.

Harrison and Rankin (*4*) reported on twelve cases with fixed-length rods on one side and self expanding rods on the contralateral side and found that eight cases presented an increase in length on the self expanding rod side, whereas three cases showed a greater length on the fixed-length rod side. They also concluded that a possible benefit to growth by using self expanding rods is not statistically significant. The explanation for growth increase with telescoping rods may result from a decreased incidence of refracture and reoperation rate and improved splinting in the growth region due to epiphysis to epiphysis spanning rather than metaphysis to metaphysis spanning in non-telescoping rods.

This paper supports the concept that most of the postoperative complications are directly related to the implant itself, either by failed expansion, T-piece migration, and mal-alignment in telescoping rods or bone outgrow in the non-telescoping rods with resultant refracture and reoperation (*5-7,12,19*). In this study the total complication rate was 28.6% in the telescoping rod group and 68.4% in the non-telescoping rod group. Harrison and Rankin (*4*) reported an overall complication rate of 64% in self-expanding rods and 93% in fixed-length nails. Porat *et al* (*14*) reported a rate of 72% for Bailey-Dubow rods and 50% for non-telescoping rods whereas Gamble *et al* (*3*) reported 69% for Bailey-Dubow rods and 55% for non-telescoping rods.

The low complication rate found in this study with telescoping rods was related to careful attention to all the technical tricks during rod insertion and the use of Sheffield rods instead of Bailey-Dubow rods, thus avoiding the complications related to T-piece detachment. Rod migration is still a common problem in telescoping and non-telescoping intramedullary rodding and, to minimise it, the rod must be placed in the centre of the medullary canal parallel to the long axis of every fragment. In telescoping rods the T-piece must be placed in the articular half of the epiphysis to avoid migration.

The linear growth of bone fixed with a non-telescoping rod is still a common problem that results in deformity and refracture distal to the rod. This study agrees with Mulpuri and Joseph (*12*), Gamble *et al* (*3*), and Marafioti and Westin (*10*) in that the survival time for telescoping rods is superior to non-telescoping rods and the reoperation rate is less. Porat *et al* (*14*) on the other hand reported no difference between telescoping and non-telescoping rods regarding survival time and reoperation rate.

In this study intramedullary rodding of the femoral segment was associated with more complications than of the tibial segment, in contrast to the findings of Zionts *et al* (*19*) who found more complications in relation to the tibial segments. Janus *et al* (*6*) found no difference between nail location and the overall complication rate.

CONCLUSION

Based on our results and the results of other authors, the Sheffield rod is currently the most successful way to stabilise the growing long bones of patients with osteogenesis imperfecta. The surgeon as well as the parents must be aware of the high incidence of complications. By avoiding technical errors during rod insertion many implant related complications can be avoided, thus increasing the rod survival rate. The Sheffield telescoping rod is superior to the non-telescoping Rush pin in terms of greater longevity and fewer complications requiring reoperations, avoiding the risk of growth disturbance and subsequently improving the ambulatory status and the quality of life. Also when the bone outgrows the Sheffield rod, the morbidity of changing the rod can be minimised by single component revision.

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