Long-term functional and quality of live assessment following post-traumatic distraction osteogenesis of the lower limb

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Abstract

Limb length discrepancy and segmental bone defects are severe complications following fractures of the lower limb. Distraction osteogenesis can be applied to lengthen consolidated bone or to bridge intercalary defects by segmental bone transport. The purpose of this study was to assess functional outcome and the long-term quality of live following post traumatic distraction osteogenesis of the lower limb. Three patients were treated with segmental transport for bone loss secondary to infection and debridement after a tibia fracture. Leg lengthening was performed in 12 patients with consolidated fractures, eight femurs and four tibias. For all patients their long term functional outcomes were evaluated with the Short Form Health Survey (SF-36) and the Lower Extremity Functional Scale (LEFS) after a mean follow up of nine years. Functional outcome indicated moderate difficulty in patients following segmental transport and a little bit of difficulty following lengthening of consolidated fractures. The SF-36 scores varied two points for physical functioning and one point for bodily pain as compared to the SF 36 norm-based scores. In all other six domains patients scores were comparable with the general population. In conclusion the quality of life and functional outcome returned to normal after post-traumatic distraction osteogenesis of the lower limb. In conclusion, the quality of life returned to a level comparable with the normal population after posttraumatic distraction osteogenesis. Functional outcome indicated moderate difficulty in patients following segmental transport and, a little bit of difficulty following lengthening of consolidated fractures.

Keywords: Posttraumatic, distraction osteogenesis, quality of live, SF-36, LEFS

Introduction

Limb length discrepancy and segmental bone defects are severe complications following fractures of the lower limb. The etiology of post-traumatic limb length discrepancy is malunion, collapse of comminuted fractures, or premature closure of the diaphysis in paediatric. Subsequently, a segmental bone defect may be the result of bone loss due to the trauma itself or due to debridement for osteomyelitis. Both situations, limb length discrepancy and a segmental defect, may have severe negative impact on the patient's quality of live and present complex treatment challenges.[1,2]

Ilizarov was one of the first who treated these patients with a modular-ring fixator and transosseous wires to stabilize the bone fragments. New bone was generated between osseous surfaces that were gradually pulled apart. He named this technique distraction osteogenesis.[3]
Distraction osteogenesis allows the surgeon to perform limb lengthening in patients with post-traumatic leg length discrepancy following fracture consolidation. Moreover, this technique may also be used for bridging intercalary defects by segmental bone transport.[3-8]

Most papers are case series describing surgical technique and complications. When functional outcome is studied this is often achieved with non-validated scores and a short follow up. To our knowledge no paper has been published which studies the relation between post traumatic distraction osteogenesis and quality of live.
The purpose of this study was to assess functional outcome and the long-term quality of live following post traumatic distraction osteogenesis of the lower limb.

Materials and methods

In the period 1997-2005, 15 adults were treated with distraction osteogenesis of the lower limb. Three patients were treated with segmental transport for bone loss secondary to infection and debridement after a tibia fracture. Leg lengthening was performed in 12 patients with consolidated fractures, eight femurs and four tibias. The demographic features of the patients are listed in Table 1.

With the use of an institutional review board-approved protocol, the medical records were reviewed and patients were contacted to return for evaluation. A retrospective analysis was performed to determine the duration of treatment and healing index. The healing index is defined by the total duration of treatment divided by the number of centimetres of new bone formation (months/cm). Furthermore, complications such as pin-track infections and secondary operations were extracted from medial records.

For all patients their long term functional outcomes were evaluated with two validated questionnaires the Medical Outcomes Study Short Form Health Survey (SF-36) and the Lower Extremity Functional Scale (LEFS). [9,10] All questionnaires were completed by the patients during their visit.

The SF-36 consists of multi-item scales that measure eight health domains: physical functioning (PF); role limitations due to physical health (RP); bodily pain (BP); social functioning (SF); vitality, energy, or fatigue (VT); general health perceptions (GH); role limitations due to emotional problems (RE); general mental health (MH); physical component score (PCS); and mental component score (MCS). Scores ranging from 0 to 100 points were derived for each domain, with lower scores indicating poorer function. These scores were converted to a norm-based score and compared with the norms for the general population of the United States (1998). In the US population each scale was scored to have the same average (50) and the same standard deviation (10 points). Consequently, on all scales, any score less than 50 falls below the general population mean. Calculating norm based scores using the Dutch and US populations provides similar results for the eight health domains. However, the weighing factors for calculating PCS and MCS for the Dutch population were not available therefore the US population was used as reference.The LEFS is a 20-item self-report measure of physical function. Each item is rated on a five point scale (0-4), with lower scores representing greater difficulty. Total scores can range from 0 to 80. Function is defined as follows: extreme difficulty or unable to perform activity (0-19 points), quit a bit of difficulty (20-39 points), moderate difficulty (40-59 points), a little bit of difficulty (60-79 points) and no difficulty (80 points).

Additionally, a standing full length anteroposterior radiograph of the lower extremities was obtained. The mechanical axis deviation (MAD) was calculated in millimetres and defined as the distance from the centre of the femoral condyles to the vertical line connecting the centre of the femoral head to the centre of the tibial plafond, which is the mechanical axis. Medial deviation of the mechanical axis was denoted as varus whereas lateral deviation was denoted as valgus malalignment.[11] In all patients postoperative limb length discrepancy was calculated as the difference between the lengths of both mechanical axes.

Operative technique

Segmental bone transport was performed for bone loss secondary to infection and debridement. Once the infection had subsided a monolateral fixator (Orthofix Dynamic Axial Fixator, Verona, Italy) was positioned over the defect. A single longitudinal periosteal incision was made over the inferior third of the tibial tuberosity for metaphyseal lengthening. Subsequently, the cortex was circumferentially predrilled with a 3.2 drill. Then, a subperiosteal corticotomy was performed by connecting the drill holes with an osteotome. **Figure 1** Special care was taken to avoid periosteal damage and to preserve intramedullary blood supply. After a latency period of seven days the bone segment was distracted with a distraction rate of one millimetre per day in four 0.25 mm increments. Once, the bone segment had reached the docking site a plate fixation with autogenous bone grafting was performed. **Figure 2**

Tibial lengthening for consolidated fractures was performed similar to the technique described above combined with an additional fibula osteotomy of two centimetres at the junction of the distal and middle thirds of the diaphysis. For femoral lengthening a subperiosteal corticotomy was established in the proximal metaphysis, corresponding with the subtrochanteric area. When lengthening was completed, the patients were encouraged to 100% weight bearing after dynamization of the fixator.

Results

The three patients who underwent segmental transport of the tibia had a mean age of 24 years (range, 22-25 years) The average amount of lengthening in these three patients was 12 ± 5 (SD). The fixators were in place for an average of 14 ± 4 months (range, 9.9-16.8 months). The mean healing index was 1.4 ± 0.9 months/cm. One patient developed a pin tract infection, which was treated with oral antibiotics. Following segmental transport, all patients were treated with a plate fixation and autogenous bone grafting to allow consolidation at the docking site. One patient was treated with an additional corrective osteotomy of the tibia due to varus angulation of the tibia. After a mean follow up of 6 ± 3 years an average LEFS score of 47 ± 12 was found.

Leg lengthening was performed in twelve patients, eight femurs and four tibias. The median age was 26 years (range, 18-51 years) in a total of two female and ten male patients. The mean amount of lengthening was 6 ± 4 cm for femoral and 4 ± 2 cm for tibial distraction osteogenesis. The fixators were in place for an average of 8 ± 5 months for femoral and 5 ± 1 for tibial lengthening. The mean healing index was 1.5 ± 1.0 months/cm in the femur and 1.6 ± 0.6 month/cm in the tibia. Five patients developed a pin tract infection in the femur and two patients in the tibia, of which two infections in the femur and one in the tibia were treated with intravenous antibiotics. The other four patients were treated for persisting fistula with operative debridement of the pin track after the fixator was removed. Osteoclasis for premature consolidation was performed in one patient during femoral distraction osteogenesis. One patient in the tibial distraction osteogenesis group underwent a talocrural artrodesis due to unacceptable pain in the ankle joint. The mean follow up was 9.6 ± 3.3 years in the femoral and 10.5 ± 3.9 years in the tibial lengthening group. The average LEFS score was 61 ± 13 points after femoral and 62 ± 18 points after tibial lengthening.

The median SF 36 scores for each of the eight health domains were: PF (48 ± 11), RP (56 ± 10), BP (49 ± 10), GH (55 ± 7), VT (57 ± 7), SF(57 ±6), RE (56 ± 4), MH (55 ± 5). For the physical and mental combined the scores were 49 ± 11 and 57 ± 6 respectively. Median SF-36 scores for all fifteen patients combined at the end of follow up are displayed in **figure 3** in comparison with US population norms.

The mean MAD was 21 ± 20 mm (range 0-59 mm) with five patients showing varus and eight patients showing valgus malalignment. One patient demonstrated no mechanical axis deviation, and in one patient no radiographs were taken due to pregnancy. The overall postoperative limb length discrepancy, defined as the difference in lengths of both mechanical axes, was 1.6 ± 1.6 cm.

Discussion

The management op patients with limb length discrepancy or segmental bone defects following fractures of the lower limb is complicated due to the protracted postoperative period of external fixation. In the three patients with segmental transport the fixators were in place for almost fourteen months and eight and five months for femur and tibial distraction respectively. On average, it takes approximately 1.5 months to grow 1 centimetre of consolidated bone. This growth rate is according to the rate described in literature.[3] During this prolonged period of external fixator use the patient is at risk for developing pin tract infections. In this case series eight out of fifteen patients developed a pin tract infection of which four patients underwent operative debridement. The prevalence of pin tract infections in literature ranges between 47 and 95%.[1,2,12] Furthermore, in the lengthening group two patients underwent an additional operation, one for premature consolidation and one talocrural arthrodesis due to unacceptable ankle pain. All segmental transport patients underwent an additional operation for plate fixation and autogenous bone grafting to allow consolidation at the docking site.

The purpose of this study was to assess the long-term quality of live and functional outcome following post traumatic distraction osteogenesis of the lower limb. After a mean follow up of nine years quality of life and lower limb function were assessed with SF-36 and LEFS questionnaires.

Only for the domains physical functioning and bodily pain the scores were slightly lower when compared with the general population. The scores varied two points for physical functioning and one point for bodily pain as compared to the SF 36 norm-based scores. In all other six domains like role limitations due to physical health; social functioning; vitality, energy, or fatigue; general health perceptions; role limitations due to emotional problems and general mental health, the patients scores were comparable with the general population.

The overall function of the lower extremity was classified as ”moderate difficulty” in the segmental transport patients and as ”a little bit of difficulty” in the lengthening group. The mean mechanical axis deviation measured was 21 mm with five patients showing varus and eight patients showing valgus malalignment.

Interpreting these results one has to realize that this is a selected case series. In general young patients as studied here are extremely motivated and cooperative Also, there could be a selection bias because operative treatment was allocated by the treating surgeon This may explain the quality of live scores which are equivalent compared with the general population in each domain. However, what this case series does show is that the quality of live in the

long run is not influenced by prolonged external fixator use and complications as pin tract infections and secondary operative interventions in these motivated, young and cooperative patients The same is true for the function of the lower extremity. Because of the long follow up these results may be influenced by coping behaviour. Nevertheless, it seems that these patients, despite the severity of the initial injuries and prolonged treatment, have little or moderate difficulties in daily activities and practising hobbies.

The mean MAD of 21 mm appeared not to influence the quality of live and functional outcome after a mean follow up of nine years. However, it may lead to a higher rate of degenerative arthritis of the knee and ankle joint. Theoretically, distraction is aimed in the direction of the mechanical axis. Application of a monolateral fixator may introduce in addition to the distraction vector a varus or valgus directive force. This especially applies when the monolateral fixator is not exactly parallel to the mechanical axis. Paley & Tetsworth already described the problem of axis deviation when using a ring fixator, due to imbalance between muscle forces on different sides of the bone. [11] They found that osteotomies of the proximal femur tend to go into varus and procurvatum. Osteotomies of the distal femur tend to go into valgus and procurvatum. Osteotomies of the proximal tibia tend to go into valgus and procurvatum and the distal tibia into varus and procurvatum.[1] The distraction system used in this study did not allow to correct for mechanical axis deviation during distraction, but newer systems offer this option. Recently, fixator assisted lengthening over an intramedullary nail was described.[12,13] The authors concluded that the duration of external fixation was reduced compared with that required for classic treatment and patients comfort was increased. In addition the intramedullary nail prevented deformation of the regenerated bone. This type of distraction osteogenesis may prevent mechanical axis deformation as well.

One of the main limitations of the present study is its small sample size. This is due the fact that the incidence of patients with posttraumatic limb length discrepancies or segmental defects due to the initial trauma or infection is relatively low. Only fifteen patients were treated in eight years in a level one trauma centre in the Netherlands. However, with the improvements in reconstructive techniques the limb salvage rate is increased. Consequently, the incidence of this kind of patients will increase. Despite its small size to our knowledge this study is unique with respect to the duration and completeness of follow up and assessment of quality of life and functional outcome data.

In this study a subperiosteal corticotomy in the metaphyseal part of the bone was performed because of greater blood flow and a thin cortex which facilitates the corticotomy.[3,14] However, other authors described good results when performing a diaphysial

corticotomy.[15-18] Fischgrund et al. reviewed 114 consecutive patients who underwent 140 lower-extremity bone-segment lengthening procedures using the Ilizarov external fixator They found that diaphyseal lengthening healed more slowly than metaphyseal lengthening.[15]

The duration of the latency period in this study was seven days. In the literature the latency period in most clinical studies has ranged from three to ten days.[3] However, in an experimental canine model the bone-healing index showed that new bone consolidation was best with a zero-day latency in metaphyseal and diaphyseal lengthening.[17]

The bone segments were distracted with a distraction rate of one millimetre per day in four 0.25 mm increments. Experimental studies have demonstrated that rates ranging from 0.5 to two millimetres per day lead to bone formation after a metaphyseal corticotomy, but more than two millimetres per day may exceed the potential for vascular ingrowth at a diaphysial site.[3,19]

The key finding of this study is that quality of life returned to a level comparable with the normal population after posttraumatic distraction osteogenesis. Functional outcome indicated moderate difficulty in patients following segmental transport and, a little bit of difficulty following lengthening of consolidated fractures. It is expected that the results of quality of life and function can be extrapolated to all young motivated and cooperative patients with limb length discrepancy or segmental bone defects, following fractures of the lower limb.

Table 1:

Demographic Data

Patient	Age (yr) at time of accident	Gender	Primary diagnosis, Open fractures have been classified according Gustilo	Lengthening procedure
1	25	F	Closed tibia shaft fracture	Segmental bone transport tibia
2	25	F	Grade II tibia shaft fracture	Segmental bone transport tibia
3	22	M	Closed tibia shaft fracture	Segmental bone transport tibia
4	18	F	Closed femur shaft and tibia shaft fracture	Primary lengthening femur
5	22	M	Grade II femur shaft fracture	Primary lengthening femur
6	20	M	Grade III tibia shaft fracture	Primary lengthening tibia
7	30	M	Grade III tibia shaft fracture	Primary lengthening tibia
8	33	M	Grade III femur shaft fracture and closed tibia shaft fracture	Primary lengthening femur
9	34	M	Grade I femur shaft fracture	Primary lengthening femur
10	18	M	Grade II tibia shaft fracture	Primary lengthening tibia
11	18	M	Grade II femur shaft fracture	Primary lengthening femur
12	41	M	Grade III femur shaft fracture	Primary lengthening femur
13	51	M	Closed femur shaft fracture	Primary lengthening femur
14	35	F	Closed tibia plateau fracture	Primary lengthening tibia
15	22	M	Grade III femur shaft and closed tibia shaft fracture	Primary lengthening femur

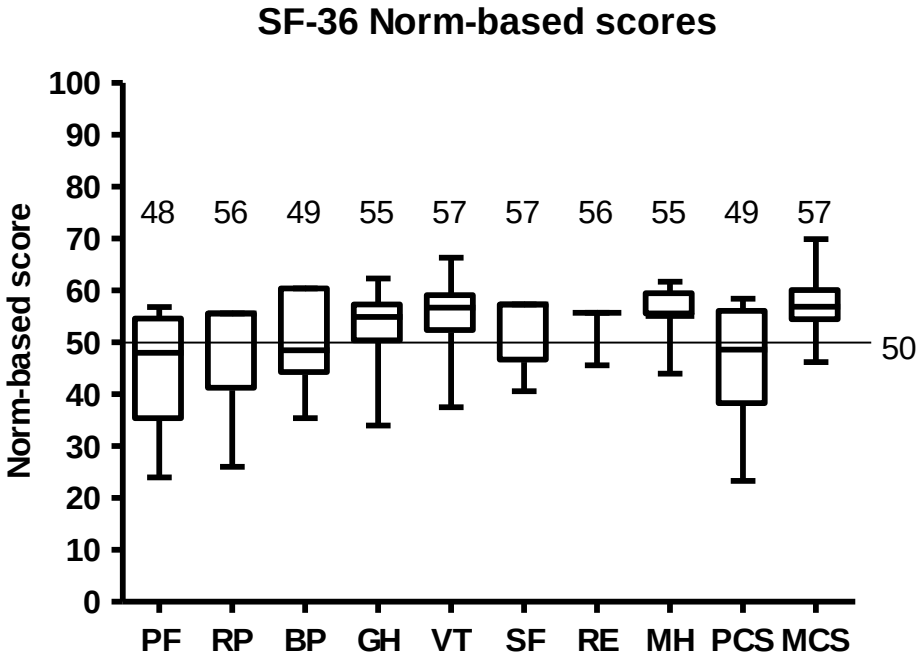
Figure 1 : A subperiosteal corticotomy was performed by connecting the drill holes with an osteotome.

Figure 2: The bone segment was distracted with a distraction rate of one millimetre per day. As soon as the bone segment had reached the docking site, a plate fixation with autogenous bone grafting was performed.

2A:

2B:

Figure 3: Median SF-36 scores leg lengthening in comparison with US population norms.



Physical functioning (PF); role limitations due to physical health (RP); bodily pain (BP); social functioning (SF); vitality, energy, or fatigue (VT); general health perceptions (GH); role limitations due to emotional problems (RE); general mental health (MH); physical component score (PCS); and mental component score (MCS). Horizontal lines within boxes, boxes, error bars represent median, interquartile range and range respectively.

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