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ORIGINAL ARTICLE

**Levent Eralp · Mehmet Kocaoğlu · Korhan Özkan
Mehmet Türker**

A comparison of two osteotomy techniques for tibial lengthening

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Abstract *Introduction:* There are various methods of long bone lengthening. The quality of the regenerated bone depends on stable external fixation, low energy corticotomy, latency period, optimum lengthening rate and rhythm, and functional use of the limb. Percutaneous corticotomy and ostetomy with multiple drill holes yield the best results for the quality of the regenerated bone. An alternative low energy osteotomy, which respects the periosteum, is the Afghan percutaneous osteotomy. The purpose of the current study was to compare a percutaneous multiple drill hole osteotomy with a Gigli saw osteotomy in terms of the healing index (HI). *Materials and methods:* Forty-four tibias of 41 patients were lengthened at our institution between 1995 and 2000. All patients underwent limb lengthening without any deformity correction by the Ilizarov device. The etiology of the limb length discrepancy was sequelae to poliomyelitis in 16 tibias, idiopathic hypoplasia in 17 tibias, posttraumatic discrepancy in 5 tibias, bilateral tibial lengthening in achondroplastic dwarfism in 3 patients. Patients with metabolic bone diseases were not included in this series. *Results:* The mean amount of length discrepancy was 5.7 cm (range 2–12 cm). The mean HI of the whole group was 1.65 month/cm (range 1.1–2.4 month/cm). When comparing the osteotomy methods without taking the etiology into consideration, the percutaneous, multiple drill hole group yielded a mean HI of 1.98 month/cm (range 1.4–2.4 month/cm), while the Gigli saw group yielded a mean HI of 1.37 month/cm (range 1.1–1.8 month/cm). There was a statistically significant difference between the two groups (p=0.022). The Gigli saw patients with poliomyelitis had a significantly better HI compared with patients who underwent lengthening by the other form of osteotomy (1.1 vs 1.9 month/cm; p=0.027). *Conclusion:* Our results confirm the biologic superiority of the Gigli saw technique.

Keywords Tibial lengthening · Percutaneous corticotomy · Gigli saw corticotomy · Poliomyelitis · Leg length discrepancy

L. Eralp · M. Kocaoğlu · K. Özkan · M. Türker
Istanbul Medical Faculty,
Department of Orthopedics and Traumatology,
Istanbul University, Istanbul, Turkey

L. Eralp (✉)
Ortopedi ve Travmatoloji Anabilim Dalı, Istanbul Tıp Fakültesi,
34390 Çapa - Istanbul, Turkey
Tel.: +90-212-6351235, Fax: +90-212-6352835,
e-mail: yeralp@superonline.com

Introduction

Since Codivilla's first report of limb lengthening in 1905, various methods have been described in the literature [1, 2, 10]. Previous methods depict techniques of rapid distraction. Current lengthening methods rely on the Ilizarov principles [4, 5]. The quality of the regenerated bone depends on stable external fixation, low energy corticotomy, latency period, optimum lengthening rate and rhythm, and functional use of the limb.

Percutaneous corticotomy and ostetomy with multiple drill holes yield the best results for the quality of the regenerated bone [3]. An alternative low energy osteotomy, which respects the periosteum, is the Afghan percutaneous osteotomy [6, 7]. In this osteotomy, a Gigli saw is passed subperiosteally around the proximal tibia by two small incisions, and the osteotomy is performed manually by low energy [7].

The purpose of the current study is to compare a percutaneous, multiple drill hole osteotomy with a Gigli saw osteotomy in terms of the healing index.

Patients and methods

Forty-four tibias of 41 patients were lengthened at our institution between 1995 and 2000. Twenty-five patients were male and 16 patients female. The mean age of the patients at the time of the operation was 23.7 years (range 9–50 years). All patients underwent limb lengthening without any deformity correction by the Ilizarov device. The etiology of the limb length discrepancy was sequelae to poliomyelitis in 16 tibias, idiopathic hypoplasia in 17 tibias, posttraumatic discrepancy in 5 tibias, bilateral tibial lengthening in achondroplastic dwarfism in 3 patients. Patients with metabolic bone diseases were not included in this series. All patients were operated on and followed up by senior two surgeons. The mean amount of length discrepancy was 5.7 cm (range 2–12 cm).

Twenty-five tibias were lengthened by a Gigli saw osteotomy, and 19 tibias were lengthened by a percutaneous, multiple drill hole osteotomy. The patients were selected randomly.

Pre- and postoperative evaluation included standing anteroposterior and lateral orthoroentgenographs of both lower limbs, a detailed neurovascular examination, and determination of the expected length discrepancy by the multiplier method [8].

The healing index (HI) was calculated to compare the effectiveness of the osteotomy techniques. HI is calculated as total duration of time in the external fixator divided by the total amount of lengthening, expressed in month(s) per centimeter.

Statistical significance was calculated by Mann-Whitney U-test, significance being set at $p<0.05$. Analysis was performed by the SPSS 7.5 for Windows software.

Results

The patients were followed-up for a mean of 37.2 months (range 18–82 months). During the external fixation period, patients were clinically and radiologically examined. The Ilizarov device was extracted after observation of solid union of the regenerated bone. Solid union was defined as depiction of at least three cortices on the regenerated bone in two orthogonal planes.

The median HI of the whole group was 1.4±0.87 month/cm (range 0.6–4 month/cm). When compared by the osteotomy method without taking the etiology into consideration, the percutaneous, multiple drill hole group yielded a median HI of 1.67±0.98 month/cm (range 0.63–4 month/cm), while the Gigli saw group yielded a median HI of 1.2±0.68 month/cm (range 0.6–3.67 month/cm). There was a statistically significant difference between the two groups ($p=0.013$). When the HIs were compared by the etiology without considering the osteotomy method, there was a statistically significant difference of HI between polio (1.79±0.74 month/cm) and non-polio patients (1.28±0.92 month/cm; $p=0.013$).

The two etiology groups were evaluated individually. There was no significant difference in HI between the two osteotomy methods within the poliomyelitis patient group. In contrast, patients with other etiologies displayed a significant difference between the HIs when compared by the osteotomy method ($p=0.02$).

The two osteotomy groups were evaluated individually. There was no significant difference in HI between the two etiology groups with the drill hole corticotomy. In contrast, patients who underwent a Gigli saw osteotomy displayed a significant difference between the HIs when compared by the etiology ($p=0.02$) (Table 1).

Table 1 Healing indices [median±SD (min–max)] of the study groups and statistical comparison (Student's *t*-test)

	Healing Index (month/cm)	Statistical difference
Whole group:	1.4±0.87 (0.6–4)	
Drill hole corticotomy	1.67±0.98 (0.63–4)	$p=0.013$
Gigli saw	1.2±0.68 (0.6–3.67)	
Poliomyelitis group:	1.79±0.74 (1–3.67)	$p=0.013$
Non-polio group	1.28±0.92 (0.6–4)	
Poliomyelitis group:	1.79±0.74 (1–3.67)	
Drill hole corticotomy	2±0.64 (1.4–3.33)	$p=0.202$
Gigli saw	1.75±0.80 (1–3.67)	
Non-polio group:	1.28±0.92 (0.6–4)	
Drill hole corticotomy	1.4±1.15 (0.63–4)	$p=0.020$
Gigli saw	1.12±0.45 (0.6–2.29)	
Drill hole corticotomy group:	1.67±0.98 (0.63–4)	
Poliomyelitis group	2±0.64 (1.4–3.3)	$p=0.23$
Non-polio group	1.4±1.15 (0.63–4)	
Gigli saw group:	1.2±0.68 (0.6–3.67)	
Poliomyelitis group	1.75±0.80 (1–3.67)	$p=0.02$
Non-polio group	1.12±0.45 (0.6–2.29)	

Discussion

Tibial lengthening by circular external fixation and gradual incremental lengthening appears to have improved results based on length attainable. The success of lengthening depends on the mechanical stability of the external fixator, functional use of the extremity, speed and frequency of lengthening, and the type of osteotomy. A low energy osteotomy which respects the periosteum provides optimum conditions for regeneration [4, 5].

Percutaneous osteotomies performed after multiple drill holes yields a healthy biologic environment for regeneration [3]. Recently, a Gigli saw osteotomy was described [6, 7], which protects the periosteum, when performed properly.

The comparison of HIs in our whole study group revealed a statistically significant variation between the drill hole osteotomy and Gigli saw osteotomy techniques in patients with tibial length discrepancy ($p=0.013$). This result confirms the biologic superiority of the Gigli saw technique. The same difference was observed when patients with sequelae to poliomyelitis were compared with patients affected by other pathologies ($p=0.013$). Poliomyelitis patients have flail limbs and exert almost no strain on the external fixator by muscle pull. As the total strain on the fixator increases the quality of the regeneration, poliomyelitis patients could be expected to have poorer HIs, without taking the osteotomy technique into consideration. Since poliomyelitis patients lack this positive effect on regeneration, a biologically more respectful osteotomy technique might favor a better regeneration. But our results displayed no significant difference between the two osteotomy techniques in the poliomyelitis subgroup. In patients with other etiologic factors like posttraumatic length discrepancy, dwarfism, etc., the Gigli saw technique provided better HIs compared with the drill hole corticotomies, which again shows the biologic superiority of the Gigli saw osteotomy technique ($p=0.02$).

We conclude that the Gigli saw osteotomy technique, which respects the periosteum more than the drill hole corticotomy, yields better HIs for tibial lengthening.

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