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Outcomes Following Lower Limb Corticotomy Using Multiple Drill-Hole and Gigli Saw Techniques During Distraction Osteogenesis: A Prospective Observational Comparative Study

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Learning Point of the Article:

Both Multiple Drill-Hole and Gigli Saw corticotomy techniques provide comparable regenerate formation and clinical outcomes during distraction osteogenesis. Preservation of the biological environment and adherence to distraction osteogenesis principles appear more important than the choice of corticotomy technique itself.

Abstract

Introduction: Corticotomy is a critical step in distraction osteogenesis, with the potential to influence regenerate formation and subsequent bone healing. Multiple drill-hole and Gigli saw corticotomy are two commonly employed low-energy techniques designed to preserve the biological environment necessary for successful osteogenesis. However, evidence comparing their clinical and radiological outcomes remains limited and conflicting. This study compares the radiological, clinical, and functional outcomes of lower limb corticotomy performed using the Multiple Drill-Hole technique and the Gigli Saw technique during distraction osteogenesis.

Materials and Methods: A prospective observational comparative study was conducted in 20 patients who underwent lower limb distraction osteogenesis between October 2019 and April 2022 in a tertiary care center. Patients were prospectively categorized according to the corticotomy technique utilized during surgery. Radiological regenerate quality was assessed at six completed weeks of distraction and categorized as hypotrophic, normotrophic, or hypertrophic regenerate. Secondary outcome was assessed by the Numeric Pain Rating Scale (NPRS), operative duration, and complications. (IEC approval no.IEC/2019/72 on October 21, 2019 of Armed forces medical college).

Results: Normotrophic regenerate was the predominant regenerate pattern in both groups. In the multiple Drill-Hole groups, regenerate morphology was normotrophic in 70%, hypotrophic in 20%, and hypertrophic in 10% of patients, compared with 80%, 10%, and 10%, respectively, in the Gigli Saw group. There was no statistically significant difference between the two groups (Fisher's Exact test, P = 1.000). NPRS score was comparable between groups, with Mann–Whitney U test values of 45.0, 47.5, and 44.0, and P = 0.63, 0.51, and 0.48, respectively. However, mean corticotomy time was significantly shorter in the multiple Drill-Hole group (10.7 min) than in the Gigli Saw group (19.9 min), with Mann–Whitney U = 0, P < 0.0001. Complication rates were comparable between groups.

Conclusion: Both multiple Drill-Hole and Gigli Saw corticotomy techniques produced satisfactory regenerate formation and comparable clinical outcomes during distraction osteogenesis. The findings suggest that preservation of the biological environment and adherence to established principles of distraction osteogenesis are more important than a specific corticotomy technique for successful bone regeneration.

Keywords: Distraction osteogenesis, corticotomy, gigli saw, multiple drill-hole, regenerate, Ilizarov, limb reconstruction.

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Introduction

Distraction osteogenesis, popularized by Ilizarov, has become an established technique for limb lengthening, deformity correction, management of bone defects, and treatment of complex non-unions [1,2,3]. The procedure is based on the principle of gradual distraction across a biologically active corticotomy site, stimulating new bone formation through the tension-stress effect while simultaneously promoting adaptation of surrounding soft tissues.[1,2,4].

Successful distraction osteogenesis depends upon multiple biological and mechanical factors, such as preservation of vascularity using low-energy corticotomy, stability of fixation, latency period, distraction rate and rhythm, and rehabilitation. Of these variables, the corticotomy technique plays a pivotal role because it directly influences the biological environment responsible for regenerate formation [1,2,4,5,6,7].

Multiple drill-hole corticotomy, as described by De Bastiani et al. [5], and the Gigli saw corticotomy popularized by Paley [6] are among the most commonly used low-energy osteotomy techniques. Although both the methods aim to minimize soft tissue injury, the relative superiority of either technique remains controversial with existing literature [8,9,10,11].

The present study was undertaken to compare regenerate quality, post-operative pain, functional outcomes, operative duration, and complications following lower limb corticotomy performed using multiple Drill-Hole and Gigli Saw techniques.

Materials and Methods

Twenty patients who underwent lower limb distraction osteogenesis between October 2019 and April 2022 at our center were included in our study. All patients were older than 18 years of age. Patients with pre-existing metabolic diseases and who underwent corticotomy for deformity correction were not included in the study. These patients were observed in two groups of ten patients each based on the type of corticotomy performed. The choice of corticotomy technique was made independently by the treating surgeon as part of routine clinical practice. Monolateral fixator limb reconstruction system (LRS) is used following corticotomy involving the femur, whereas Ilizarov ring fixator is used in all cases involving the tibia. Patients were subsequently categorized according to the technique utilized. Group A included patients who underwent corticotomy using multiple Drill-Hole technique and Group B with Gigli Saw technique.

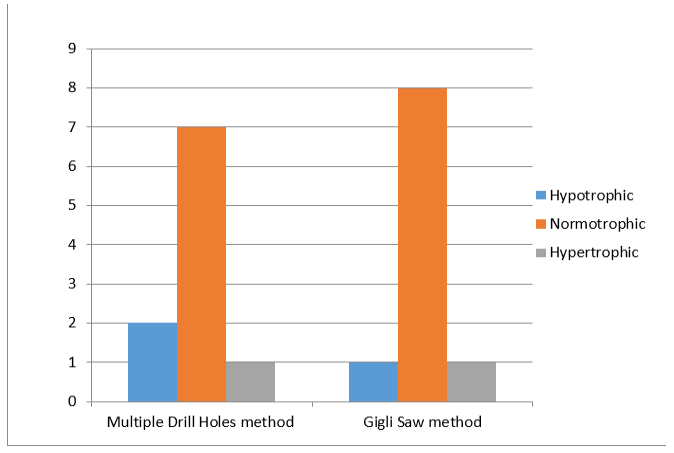


Figure 1: Graph representing quality of regenerate.

In both groups, a latency period of 7 days was observed before the start of distraction. Distraction was done at a rate of 1 mm in 24 h, divided as 0.25 mm every 6 h in both groups. The patients were monitored clinically and radiologically by weekly X-rays during the distraction phase and monthly in the consolidation phase. Radiological regenerate quality was assessed after six completed weeks of distraction and categorized as hypotrophic regenerate, normotrophic regenerate, hypertrophic regenerate as described by Catagni [12] (Fig. 1, 2, 3). Post-operative pain was assessed using Numeric Pain Rating Scale (NPRS) on post-operative day (POD) 1,7 and 28.

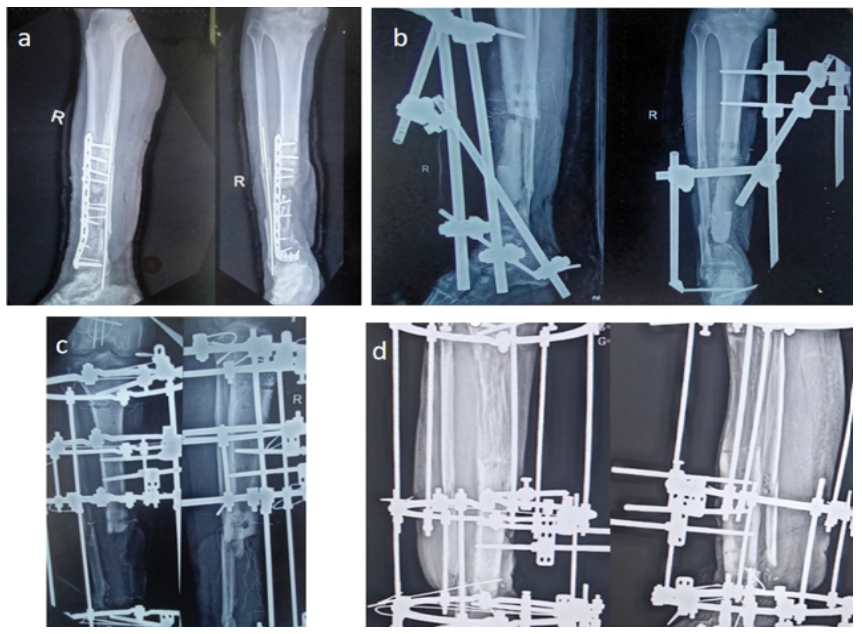


Figure 2: Radiograph of a patient with infected non-union distal shaft of right tibia. (a) Pre-operative radiograph. (b) Radiograph following implant removal and debridement along with antibiotic-loaded cement spacer and external fixator application. (c) Radiograph showing proximal tibial corticotomy using multiple drill hole method. (d) Normotrophic regenerate following bone transport.

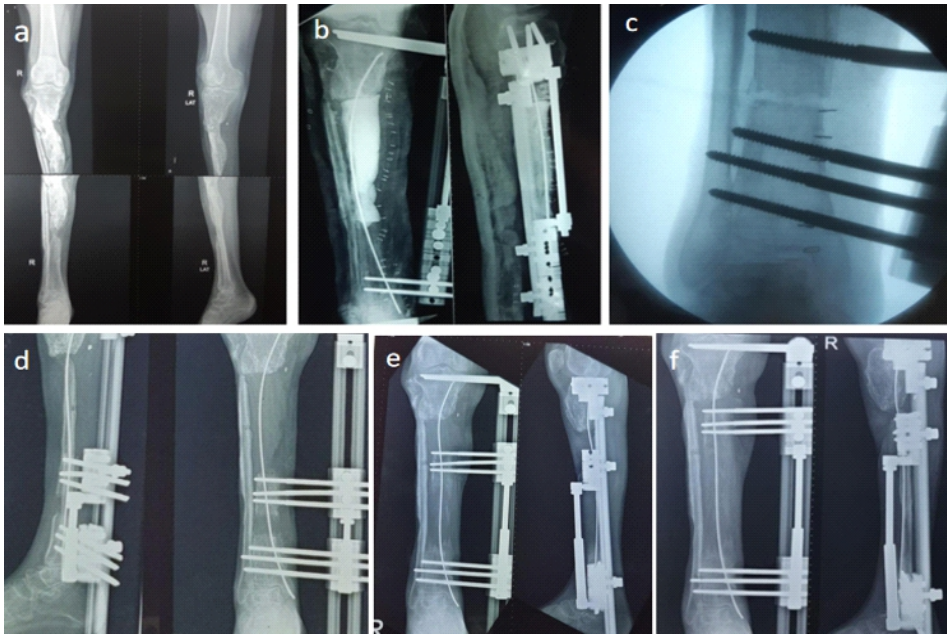


Figure 3: Radiograph of patient with infected non-union mid-shaft of right tibia. (a) Pre-operative radiograph. (b) Radiograph following debridement with limb reconstruction system and antibiotic-loaded cement spacer application. (c) Distal tibial coticotomy using Gigli saw method. (d and e) Radiograph showing ongoing bone transport. (f) Hypotrophic regenerate following bone transport.

Statistical analysis

Continuous variables were analyzed using the Mann–Whitney U test, while categorical variables were compared using Fisher's Exact test.

Results

A total of 20 patients were included in the study, with ten patients in each group. The mean age was 31.8 years in Group A and 31.7 years in Group B. The corticotomy was done in the tibia for 8 patients of Group A, with the remaining 2 being femur, whereas in Group B, 9 cases involved tibia and 1 was femur. All cases of femoral lengthening were done using a monolateral fixator LRS, whereas all cases of tibia underwent lengthening using Ilizarov ring fixator. All cases of femoral lengthening were done using proximal diaphyseal corticotomy. However, proximal metaphyseal corticotomy was utilised in all cases involving tibia except 2 cases in each group, where a distal metaphyseal corticotomy was done. Except 1 case of post-traumatic bone loss in each group, all other patients were a case of infected non-union.

Table 1: Radiological quality of regenerate

Regenerate type	Group A Multiple drill holes method *n* (%)	Group B Gigli saw method *n* (%)
Hypotrophic	2 (20)	1 (10)
Normotrophic	7 (70)	8 (80)
Hypertrophic	1 (10)	1 (10)

The average time taken exclusively for the corticotomy part during the surgery was 10.7 min (95% confidence interval [CI]: 9.48–11.92) in Group A in comparison to 19.9 min (95% CI: 17.96–21.84) in Group B (Mann-Whitney U = 0, P < 0.0001), showing a statistically significant difference between the two groups.

The quality of regenerate was compared radiographically at 6 completed weeks of distraction in all the participants. There were 7 cases of normotrophic, 2 hypotrophic, and 1 hypertrophic regenerate in Group A whereas 8 normotrophic, 1 hypotrophic and 1 hypertrophic regenerate in Group B; with Fisher's Exact test, P = 1.000. The result showed no statistically significant difference between two groups (Table 1).

The NPRS score was recorded on PODs 1, 7, and 28 (Table 2). The difference in the two groups was not significant, with Mann–Whitney U test values of 45.0,47.5,44.0 and P = 0.63,0.51 and 0.48, respectively. The mean duration of distraction was 58.3 days in Group A and 67.5 days in Group B.

Complications

Complication rates were comparable between groups. Pin tract infection occurred in two patients in each group, which was managed with local wound care and oral antibiotics. One patient in Group A developed posterior tibial artery pseudoaneurysm, which was managed conservatively. One patient in Group A developed chronic infection requiring surgical debridement. Pre-mature regenerate consolidation requiring repeat corticotomy occurred in one patient in Group A. One patient in each group developed equinus deformity requiring tendo-Achilles lengthening. One patient in Group B developed soft tissue impingement at the compression site for which he underwent surgical release. However, no cases of osteomyelitis, perioperative fracture, incomplete corticotomy, valgus deformity, or recurvatum deformity were observed.

Discussion

Distraction osteogenesis remains one of the most powerful

Table 2: Post-operative pain scores

NPRS	POD 1	POD 7	POD 28
Group A	7.1	5.4	3.6
	(95% CI : 6.52–7.68)	(95% CI : 5.05–5.75)	(95% CI : 3.24–3.96)
Group B	6.9	5.35	3.3
	(95% CI : 6.34–7.46)	(95% CI : 4.98–5.72)	(95% CI : 2.96–3.64)
Mann-Whitney U test	45	47.5	44
P-value	0.63	0.51	0.48

NPRS: Numeric pain rating scale, CI: Confidence interval, POD: Post-operative day

biological methods for limb reconstruction and is founded on the tension-stress principles described by Ilizarov. Successful regenerate formation depends upon multiple factors, such as preservation of vascularity, mechanical stability, and adherence to appropriate distraction protocols [1,2,4]. Among these variables, the corticotomy technique plays a pivotal role because it directly influences the biological environment responsible for regenerate formation.

The principal finding of the present study was that both multiple Drill-Hole and Gigli Saw corticotomy techniques produced comparable regenerate quality during distraction osteogenesis. Normotrophic regenerate was the predominant regenerate pattern in both groups, and no statistically significant difference was observed in regenerate morphology. Similarly, post-operative pain scores, functional outcomes, and complication rates were comparable between the two techniques.

The theoretical basis for comparing these techniques lies in their differing effects on periosteal and endosteal blood supply. The Gigli Saw technique has traditionally been regarded as biologically advantageous because the corticotomy is performed through a subperiosteal passage of the saw, minimizing soft tissue disruption and preserving periosteal vascularity. In contrast, the multiple Drill-Hole technique requires repeated cortical perforations and completion with an osteotome, theoretically increasing local tissue trauma. Despite these theoretical differences, both techniques are low-energy corticotomies designed to preserve osteogenic potential.

The present findings demonstrated no statistically significant difference in regenerate morphology, post-operative pain, functional outcomes, or complication rates between the Multiple Drill-Hole and Gigli Saw corticotomy techniques. These observations are consistent with the findings of Peek et al., who compared two proximal tibial osteotomy techniques and reported comparable healing characteristics despite technical differences between procedures [11].

In contrast, Eralp et al. reported significantly superior healing indices following Gigli saw corticotomy and attributed this advantage to improved preservation of periosteal vascularity and reduced soft-tissue trauma [8]. Similarly, Makhdoom et al. observed significantly lower modified healing indices in patients undergoing Gigli saw osteotomy and concluded that preservation of periosteal blood supply may enhance regenerate consolidation [9].

More recently, Rana et al. reported superior healing indices in the multiple drill-hole group and suggested that meticulous preservation of the biological environment, rather than the specific osteotomy technique itself, may be the determining factor for successful regenerate formation [10].

The regenerate morphology observed in the present study may be interpreted according to the regenerate patterns described by Catagni [12]. Normotrophic regenerate, which predominated in both groups, reflects an optimal biological response characterized by adequate vascularity, balanced osteogenesis, and appropriate mechanical stability. Hypotrophic regenerate is generally associated with impaired biological activity or inadequate vascularity, whereas hypertrophic regenerate may represent abundant osteogenic activity occurring under conditions of relative instability. The predominance of normotrophic regenerate in both groups suggests that both corticotomy techniques successfully preserved the biological pre-requisites necessary for distraction osteogenesis.

The conflicting findings reported by Eralp et al., Makhdoom et al., Peek et al. [11], and Rana et al. suggest that the biological influence of corticotomy technique is likely smaller than the influence of fixation stability, distraction protocol, and surgical execution. The present findings support this concept, as theoretical biological advantages did not translate into significant differences in regenerate quality or functional outcomes.

Furthermore, regenerate assessment was based on conventional radiographic morphology. Recent literature suggests that quantitative assessment methods, such as pixel value ratio analysis, bone densitometry, and computed tomography-based evaluation may provide more objective measurements of regenerate maturation and healing potential [13].

An important finding of the present study was the significantly shorter operative duration associated with the multiple Drill-Hole technique, which is in concurrence with a recent study by Rana et al. [10]. Although regenerate quality and clinical outcomes were comparable, the reduced operative time may offer practical advantages, particularly in lengthy reconstructive

procedures where surgical efficiency is desirable.

The strengths of the present study lie in its prospective observational design standardized follow-up protocol, and direct comparison of two commonly employed low-energy corticotomy techniques within the same clinical setting. Furthermore, the simultaneous assessment of radiological regenerate quality, post-operative pain, functional outcomes, operative duration, and complications provides a comprehensive evaluation of treatment effectiveness. The study also contributes to the limited body of comparative literature examining the influence of corticotomy technique on outcomes during distraction osteogenesis.

However, this study has several limitations. The sample size was relatively small, limiting statistical power. The study was conducted at a single center and included predominantly young patients with minimal comorbidities, potentially limiting generalizability. Surgical outcomes in distraction osteogenesis are influenced by surgeon experience, rehabilitation protocols, and patient compliance, factors that may not be completely controlled in an observational study design. Finally, regenerate assessment was based on conventional radiographic morphology rather than quantitative techniques, such as pixel value ratio analysis or computed tomography-based assessment.

Conclusion

Both multiple Drill-Hole and Gigli Saw corticotomy techniques produced satisfactory regenerate formation and comparable clinical outcomes during distraction osteogenesis, with no statistically significant differences observed in regenerate quality, post-operative pain, functional outcomes, or complication rates. The multiple Drill-Hole technique was associated with a significantly shorter operative duration. These findings suggest that meticulous preservation of the biological environment and adherence to the principles of distraction osteogenesis may be more important determinants of successful bone regeneration than the specific corticotomy technique employed. Both methods therefore remain effective options for lower limb reconstruction.

Ethics Committee Approval

This study was approved by the Ethics Committee of Armed Forces Medical College vide no.IEC/2019/72 on October 21, 2019.

Clinical Message

Both Multiple Drill-Hole and Gigli Saw corticotomy techniques are reliable low-energy corticotomy methods for distraction osteogenesis. When meticulous surgical technique and standard distraction protocols are followed, regenerate quality and functional outcomes are comparable irrespective of the corticotomy technique employed.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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