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Peroneal palsy and non-union after closing wedge high tibial osteotomy: Does surgical technique matter?

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Abstract

Background: High tibial osteotomy (HTO) is a standard procedure for treating unicompartmental knee osteoarthritis with varus malalignment. Lateral closing wedge hybrid HTO requires managing the fibula for proper tibial correction. This study compares the outcomes of two distinct techniques-segmental fibular excision and oblique osteotomy, focusing on nonunion at the fibular osteotomy site and peroneal nerve palsy.

Methods: A retrospective study of 85 patients who underwent lateral closing wedge hybrid HTO. Patients were divided into fibular excision (n=53) and fibular oblique osteotomy (n=32) groups and were followed up for 2 years. Clinical outcomes included union rates, nonunion, delayed union, revisions, and peroneal nerve palsy incidence. PROMs like Oxford Knee Score(OKS), WOMAC Score, Knee Society Score(KSS) and Knee Society Score-Function(KSSF) with treatment were evaluated. Radiological assessment included Pre and post-operative FTA angle, and presence or absence of non-union at the fibular site. Chi-square tests were used for statistical analysis.

Results: At a minimum 2- year follow up, there were no statistically significant differences in the mean FTA, KSS and KSSF scores of both the groups. Union rates were 30% (n=16) in fibula excision and 71% (n=23) in oblique osteotomy group. Nonunion was 66% (n=35) in excision and 18% (n=6) in oblique (p<0.001). Only 2 patients out of 41 non-union (4.87%) had pain at fibular site and required revision. Peroneal nerve palsy occurred in 15 patients (18.8%; 8 in excision [15%], 7 in oblique [21%]; (p>0.05) with no statistical significant difference.

Conclusion: Fibular oblique osteotomy yields comparatively higher union rate than fibular excision. No significant difference in peroneal nerve palsy incidences between the two techniques.

Keywords: High tibial osteotomy, fibular management, non-union, peroneal nerve palsy, closing wedge HTO

Introduction

High Tibial Osteotomy (HTO) is a highly recommended procedure for treating unicompartmental knee osteoarthritis with varus malalignment. The lateral closing wedge hybrid HTO (LCWHTO) is particularly noted for its efficacy in correcting severe deformities. A crucial step in this procedure is managing the fibula to enable appropriate tibial correction. This is commonly accomplished through two distinct techniques: fibular oblique osteotomy and segmental fibular excision. While both techniques aim to achieve the same goal, their impact on complications like nonunion at the osteotomy site and peroneal nerve palsy is controversial. In order to improve surgical outcomes and patient satisfaction, this study intends to address gaps in understanding of the relationship between fibular osteotomy and its techniques in terms of outcome, nonunion, and palsy rate. It focuses on potential etiological mechanisms of the neurological deficit using statistical analysis of retrospective data. The hypothesis is that the incidence of peroneal nerve palsy associated with oblique osteotomy will be lower than excision group and there will be less incidence of non-union in oblique osteotomy.

Materials and Methods

Study Design and Patient Population

A retrospective study was conducted on a patient population of 85 individuals (58 females and 27 males) who underwent lateral closing wedge HTO between November 2012 and December 2024 at a single institution.

The study was approved by the institutional review board and all aptients provided informed consent. Data collection involved comprehensive review of electronic medical records, including demographics, surgical details, postoperative complications, and follow-up outcomes extending up to 24 months. The cohort was systematically stratified into two distinct groups based on the technique employed for fibular management - fibular excision group and oblique osteotomy group. The fibular excision group consisted of 53 patients (39 females and 14 males), while the fibular oblique osteotomy group included 32 patients (19 females and 13 males). Baseline characteristics demonstrated comparability between the groups. The fibular excision group had a mean age of 57.39 years (range: 44−70 years) and a mean Body Mass Index (BMI) of 26.88 (range: 20.76−36.96). The oblique osteotomy group exhibited a mean age of 59.78 years (range: 44−69 years) and a mean BMI of 25.76 (range: 20.08−30.99).

Indication for surgery

Inclusion criteria: (1) diagnosis of medial compartment knee osteoarthritis with varus malalignment (mechanical axis deviation >5°); (2) LCW-HTO performed using hybrid technique (biplanar tibial cut with fibular osteotomy and locking plate fixation); (3) minimum 24 months follow-up**.**

Exclusion criteria: (1) prior knee surgery (2) inflammatory arthritis (3) severe comorbidities and (4) incomplete follow-up data.

Surgical technique

All procedures were performed by one senior orthopedic surgeon experienced in HTO and at a single centre. Preoperative planning to determine the required wedge resection used a double-limb standing full-length anterior-posterior (AP) radiograph. The post-operative mechanical axis was planned such that the Weight Bearing Line (WBL) passes through 63% laterally from the medial edge of the tibial plateau. A hybrid closing wedge HTO was performed following the standardized technique described by Takeuchi et al. [1] The hinge point for the osteotomy was established by dividing the proximal tibial osteotomy line in about 2:1ratio from lateral to medial. The tibial osteotomy involved a biplanar cut with lateral closed wedge bone block removal. A proximal lateral tibia locking compression plate (Synthes, Solothurn, Switzerland) was used for fixation. The objective of the intervention was to obtain FTA less than 174°.

Fibular Osteotomy

Fibular osteotomy, performed concurrently with the tibial osteotomy in all cases, was done at the mid-diaphyseal level to minimize peroneal nerve risk with 7-8 cm. skin incision. Following longitudinal fascial incision the anterior portion of Peroneus Longus muscle was separated from facia and anterior intermuscular septum and subsequently retracted posteriorly. The muscle fibres were gently split to expose the lateral fibular surface. Both the anterior and posterior margins of the fibula were identified, and the periosteum, along with the anterior intermuscular septum and Extensor Digitorum Longus (EDL) muscle fibers, was stripped from the medial surface Similarly, the posterior intermuscular septum and Flexor Hallucis Longus (FHL) muscle fibers were stripped until the medial crest. Two Curved flat retractors were circumferentially positioned to isolate the fibula from all surrounding soft tissues. Two distinct methods were used namely fibula segment excision (53 patients) and an oblique osteotomy (32 patients). In fibular excision method, a 2-2.5 cm segment was marked and resected protecting nearby soft tissues. In oblique osteotomy a cut at an acute angle was made anterior to posterior. The superficial peroneal nerve was visualized and protected through meticulous dissection during both techniques.

Post-operative Rehabilitation

Postoperatively, on day after surgery both active and passive ROM exercises with continuous passive motion started and continued until 2 weeks. Partial weight bearing started at 4 weeks, followed by gradual progression to full weight bearing as tolerated and based on radiographic evidence of healing.

Evaluation

Patients underwent scheduled clinical and radiological follow-up evaluations at 2 weeks, 6 weeks, 3 months, 6 months, 12 months, and annually thereafter, with a mean follow-up duration of 2 years. Outcomes were assessed using clinical examination, radiological imaging, and Patient-Reported Outcome Measures(PROMs) administered pre- and post-operatively. The PROMs used were Knee Society Score (KSS) for pain assessment, Knee Society Score-Function (KSSF) for functional activities, Oxford Knee Score (OKS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score. Additionally, postoperative pain specifically at the fibular osteotomy site was evaluated and responses were recorded.

Patients were rigorously monitored for all components of peroneal nerve palsy immediately after surgery and at all subsequent follow-up visits upto 2 years. Muscle power was graded according to the MRC scale and sensation tested for light touch and pin prick.

Specific components of nerve palsy evaluated were:

- Deep Peroneal Nerve Palsy: Motor power of ankle and toe dorsiflexors and sensation in 1st web space.
- Isolated Extensor Hallucis Longus (EHL) weakness: Weakness of great toe dorsiflexion
- Superficial Peroneal Nerve Palsy: Sensory changes over the dorsum of ankle and foot

Radiological assessment included pre and postoperative measurement of the Femorotibial Angle (FTA) using weight-bearing, full-length anteroposterior (AP) radiographs. Fibular healing was evaluated to determine the status of nonunion. This involved standard AP and lateral radiographs of the leg, supplemented by Computed Tomography (CT) scans when necessary, to observe and document the state of bridging callus. Union was defined radiographically based on the US Food and Drug Administration (USFDA) criteria as the presence of bridging callus. Delayed union was defined as the absence of healing prior to 6 months, while nonunion was confirmed by the lack of healing at 9 months, specifically with 3 consecutive months demonstrating no radiological progression of healing.

Statistical Analysis

Cases with incomplete follow-up or missing outcome data were excluded using listwise deletion. Statistical analysis were performed using SPSS software (version 25.0,SPSS

Inc., Chicago, IL). Descriptive statistics were used to summarize patient demographics and clinical scores. Data for fibular excision group and oblique osteotomy group were evaluated separately. The pre-operative and final follow up (2 years) values of the FTA, KSS and KSSF were compared by a paired t-test. Statistical significance was assumed for p values less than 0.05. A chi-square test was performed to compare the rates of nonunion and peroneal nerve palsy between the two surgical groups.

Result

Patient Demographics

Of the 85 cases of LCWHTO, 53 were performed with fibular segment excision and 32 were performed with oblique osteotomy. Baseline characteristics including age, Body Mass Index (BMI), and pre-operative FTA angle of the two groups showed no significant differences (Table 1) Mean pre-operative FTA angles were 177.90° and 178.35° in the fibular excision and oblique osteotomy groups, respectively. PROMs of patients preoperatively ie. KSS (p value 0.09) and KSSF (p value 0.098) scores of the two groups showed no significant difference.

Table 1: Patient Demographics and Preoperative data

Parameters	Fibular Excision (n=53)	Oblique Osteotomy (n=32)	P value
Age (mean±SD)	57.39±6.0	59.78±5.75	0.0768
BMI (mean±SD)	26.88±3.67	25.76±2.35	0.0602
Pre KSS	44.7±7.19	41.18±9.92	0.09
Pre KSSF	52.35±8.5	52.50±9.68	0.098
Pre FTA	177.90±0.99	178.35±1.19	0.08

Data are presented as mean±standard deviation

Clinical Outcomes

At the minimum 2 year follow up, patients of both the groups assessed and there were no significant differences in the post-operative scores and FTA of both the groups implying that the KSS, KSSF score and FTA improved similarly in both the groups (Table 2). The mean post-operative KSS was 92.47 in the fibular excision and 93.93 in the oblique osteotomy group. The mean post-operative KSSF was 83.96 and 84.68 in the fibular excision and oblique osteotomy groups respectively. The mean post-operative FTA angle being 172.64 and 172.52 in fibula excision and oblique osteotomy groups respectively. At the final follow up, patients of both the groups demonstrated significant improvement in KSS, KSSF score and FTA (p value <0.002 for all) (Table 3).

In terms of bone healing, the fibular excision group had a union rate of 30% (16 cases), while the oblique osteotomy group had a significantly higher union rate of 71% (23 cases) (Table 4). Nonunion was present in 66% (35 cases) of the fibular excision group and 18% (6 cases) of the oblique osteotomy group with statistically significant difference (χ^2=17.64, p<0.001). Delayed union occurred in 3% of the fibular excision group and 9.3% of the oblique osteotomy group. Only 2 patients out of 41 non-union (4.87%) had pain at fibular site and required revision.

Of the 85 patients, 15 experienced peroneal nerve palsy, with 8 cases in the fibular excision group and 7 cases in the fibular oblique osteotomy group. The incidence of peroneal nerve palsy was 15% in the fibular excision group and 21% in the oblique osteotomy group with statistically no significant difference (p>0.05). The presence and type of neurological deficit was evaluated immediately after surgery and at subsequent follow up and the status of improvement was recorded.

At the minimum 2 year follow up, all 4 patients with isolated EHL weakness recovered fully (MRC grade 5) with no residual weakness. All 6 patients with sensory loss or paraeshesia in the cutaneous distribution of superficial peroneal nerve recovered fully. In our study, 3 out of 5 patients with deep peroneal nerve palsy had a full recovery of power of dorsiflexors and abnormal sensation at 1st web space. Other 2 patients had minor disability of ankle and toe dorsiflexors (MRC grade 4) with 80% recovery of sensation at 1st web space.

Table 2: Clinical outcome at minimum 2-year follow up

Parameters	Fibular Excision (n=53)	Oblique Osteotomy (n=32)	P value
Post KSS	92.47±10.87	93.93±8.52	0.67
Post KSSF	83.96±8.97	84.68 ±10.6	0.42
Post FTA	172.64±1.28	172.52±2.67	0.82
WOMAC score	6.15±13.2	4.18±8.71	0.41
OKS score	43.16±6.91	44.56±4.66	0.17

Data are presented as mean±standard deviation

Table 3: Comparision of Pre & Post -operative outcomes

Parameters	Fibular Excision group Mean (SD)	Oblique Osteotomy group Mean (SD)	p value
KSS	48.32(12.9)	42.75(13.7)	0.001
KSSF	34.6(7.38)	32.18(10.4)	0.002
FTA	5.25(1.67)	5.87(2.94)	0.0001
OKS	43.16(6.91)	44.56(4.66)	0.001

Table 4: Surgical Outcomes

Outcome	Fibula Excision Group	Oblique Osteotomy Group
Total Patients	53	32
Union	16 (30%)	23 (71%)
Nonunion	35 (66%)	6 (18%)
Delayed Union	2 (3%)	3 (9.3%)
Revision	1	1
Peroneal Nerve Palsy	8 (15%)	7 (21%)

Table 5: Types of Peroneal Nerve Palsy

Type of Palsy	Fibular Excision	Oblique Osteotomy
Deep Peroneal Nerve Palsy	3	2
Isolated EHL Weakness	2	2
Superficial Nerve Palsy	3	3

Discussion

This retrospective study yields significant data comparing the clinical and radiological outcomes of two distinct fibular management techniques fibular excision and oblique osteotomy in LCW-HTO. The present study established three principle findings. First, the oblique osteotomy group exhibited a significantly higher rate of bone union at fibular osteotomy site than the fibular excision group. Second, while both techniques proved effective in achieving substantial clinical and radiological improvement, the specific choice of fibular osteotomy technique does not have a statistically significant impact on the incidence of postoperative peroneal nerve palsy. Third, though fibular non-union is a common radiological finding but is largely asymptomatic and rarely requires revision surgery.

Valgus high tibial osteotomy as currently practiced, was introduced in 1958 by Jackson and Wagh, using a ball and socket type of tibial osteotomy with osteotomy of fibula at its middle third [2]. The fundamental principle of mechanical axis correction by shifting the load bearing forces from the diseased medial compartment to the healthier lateral compartment has remained constant. However, significant modifications have evolved, particularly concerning the method of fibular management. Coventry et al. used fibular head excision [3] and thereafter, the diversity of fibular management techniques has led to several comparative studies to analyze the incidence of fibula-related complications. Kurosaka et al. compared enucleation and morcelization of fibular head with midshaft fibular osteotomy in LCWHTO [4]. Bauer et al. in their study compared high and low fibular osteotomy, proximal tibiofibular disarticulation and the omission of fibular surgery, specifically in relation to the incidence of peroneal nerve palsy [5]. The precise selection of the fibular osteotomy site is recognized as critical. Consistent with prior recommendations from authors such as Wootten and Rupp R.E., our study utilized the mid-diaphyseal level [6]. This current comparative study highlights the clinical outcomes among the two common techniques of midshaft fibular osteotomy: segmental excision and oblique osteotomy.

In the present study, at the two-year follow up, both surgical cohorts demonstrated significant and statistically similar improvements across all outcome metrics, including KSS, KSSF and Femorotibial Angle (FTA). This indicates that both fibular management strategies successfully facilitate the primary surgical objective of the HTO: effective varus malalignment correction and consequent correction in knee function. The positive clinical outcomes observed in both groups can be partially attributed to the hybrid technique as described by Takeuchi et al., provides favorable biomechanical properties for optimal bone healing and supports early postoperative weight-bearing protocols.

An important finding of our study is the significantly higher union rate observed in the fibular oblique osteotomy group (71%) compared to the fibular excision group (30%). This outcome aligns with the biomechanical principles proposed by previous research by M. Ramanoudjame et al. stating that the nonunion rate is correlated with two technical factors: obliquity of the osteotomy plane and the contact surface area of the fragments [7]. The oblique osteotomy, as described by Kondo et al., is a procedure that creates a broader surface area for bone-to-bone contact, which facilitates the formation of a bridging callus and promotes bone union [8]. Conversely, segmental excision involves the removal of a bone segment, thereby eliminating direct contact between the fibular ends predisposing the site to nonunion. Despite the high overall incidence of nonunion in our cohort (66%), our study found that this complication was largely asymptomatic and rarely clinically consequential, requiring revision in only 2 out of 41 nonunion cases. This finding aligns with the study by Kurosaka et al. which reported a similar incidence of non-union (65%) following midshaft fibular segment excision [4]. This suggests that isolated fibular nonunion following HTO is often a benign radiographic finding that does not adversely affect the overall outcome of the procedure, provided that the primary tibial osteotomy has healed.

In our Study, the overall incidence of Peroneal Nerve Palsy is 17.5%, consistent with the broad range of rates (0% to 20%) previously reported in the literature [9]. In this present study, all observed cases of isolated EHL weakness and superficial peroneal nerve palsy were transient in nature and resulted in full functional recovery. This pattern is indicative of a subtle or neurapraxic injury sustained during the fibular osteotomy procedure. The incidence of deep peroneal nerve palsy was similar between the two groups (3.5% in the excision group and 2.3% in the oblique osteotomy group), with no statistically significant difference. This similarity between the two groups suggests that in addition to direct damage to the deep peroneal nerve, there is a possibility of another mechanism, that warrants further investigation.

The precise mechanism of deep peroneal nerve injury during HTO remains uncertain. However, the finding in the present study of statistically similar nerve palsy rates across both the groups supports the hypothesis that the injury can possibly attributed to a stretching mechanism during the correction of varus deformity, a process that is independent of the fibular osteotomy technique used. The inference of our study is supported by three key lines of evidence:

1. **Anatomical location:** Our surgical protocol specified fibular osteotomy at the mid-diaphyseal level (16-20 cm distal to the fibular head) which is distal to the main branching point where the deep peroneal nerve supplies the tibialis anterior muscle [9-11]. Therefore, a direct iatrogenic injury to the deep peroneal nerve at the fibular osteotomy site is highly improbable.
2. **Efficacy of prophylactic release of nerve:** Findings from studies by S. Zaffagnini and Mahmoud, who performed proximal tibio-fibular joint separation with release of common peroneal nerve, reported a complete absence of neurological deficit [12, 13]. This suggests that releasing constrictive structures is paramount to nerve preservation [14].
3. **Mechanical vulnerability: Bauer et al**. highlighted the role of mechanical damage, describing the inherent vulnerability of deep peroneal nerve to stretching injury owing to its entrapment within fibro-osseous tunnels both proximal and distal to the osteotomy site [5].

Collectively, the anatomical level of our mid-diaphyseal fibular osteotomy, the observed advantage of prophylactic nerve release in existing literature, and the documented susceptibility of the deep peroneal nerve to mechanical tension strongly point towards stretching injury as the probable etiological factor for the deep peroneal nerve palsy observed in our cohort.

The observed weakness of ankle and toe dorsiflexors is a common post-HTO complication, emphasizing the persistent possibility of direct injury to the deep peroneal nerve or its motor branches at fibular osteotomy site [15]. This risk is increased by the anatomical complexity highlighted in cadaveric studies by A. Kirgis and Georgoulis, which document significant anatomical variations in the motor nerves supplying the Tibialis anterior and EHL close to fibular periosteum [16, 17]. Therefore, we propose that the etiology of this neurological complication is primarily governed by two mechanisms: indirect mechanical damage resulting from nerve stretching during varus deformity correction and local anatomical variations that predispose the nerve to direct iatrogenic injury.

This study has several limitations. Its retrospective design and relatively small sample size may limit the generalizability of our findings. Additionally, all procedures were performed by a single surgeon and at a single centre, which introduces a potential for bias and may not reflect outcomes across different surgical settings and skill levels. However, this single-surgeon approach also ensures consistency in surgical technique, which strengthens the validity of the comparison between the two groups. Future research must move towards large scale randomized controlled trials to confirm safety and efficacy of the procedures and to control for potential selection bias. Further prospective studies are needed to explore how variables, such as surgical approach, soft tissue handling, nerve exploration or release influence outcomes. Despite these limitations, our study provides valuable clinical data on the comparative outcomes of fibular excision and oblique osteotomy, which can help guide surgical decision-making.

Conclusion

In this retrospective comparative study of two fibular management techniques fibular oblique osteotomy and segmental excision used in lateral closing wedge hybrid High Tibial Osteotomy (LCW-HTO), there was no significant difference in post-operative clinical outcomes and final varus correction among both the groups at a minimum two-year follow up. The oblique fibular osteotomy demonstrates a comparatively higher rate of union at the fibular site relative to fibular excision. Fibular nonunion is a common radiographic finding rarely causing pain.

There was no significant difference in the incidence of peroneal nerve palsy among both groups. The observed neurological deficits maybe attributable to nerve stretching during the correction of deformity or to local anatomical variations in the motor nerves supplying ankle and toe dorsiflexors.

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Author's Contribution

Not available

Conflict of Interest

Not available

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