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ORIGINAL ARTICLE

Early Results of Operative Treatment of Freiberg Disease Using Extra Articular Dorsal Closing Wedge Osteotomy

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ABSTRACT

Background: For Freiberg disease, extra-articular dorsal closure wedge osteotomy has been utilized with good results; nonetheless, there have been concerns about technical difficulty. We aimed to evaluate the outcome of the dorsal closings wedge osteotomy in addition to the debridement application on Freiberg disease in terms of functional recovery and pain relief.

Methods: 12 Freiberg disease patients who received an extra-articular dorsal closure wedge osteotomy at Zagazig University Hospitals over a 6-month period were included in the study.

Results: One intraoperative bone fragmentation complication and one postoperative infection occurred. All patients had reduced toe flexion postoperatively. The mean preoperative pain score of 8.67 decreased to 1.33 postoperatively (p=0.002), an 85.8% improvement. Radiographic staging improved from stages III/IV preoperatively to all stage II postoperatively (p=0.001).

Conclusion: Combining soft tissue and bone release reduces joint load and stress while tolerably limiting range of motion, mostly flexion and some extension.

Keywords: Freiberg Disease; Extra-articular; Wedge Osteotomy

INTRODUCTION

It was discovered by Freiberg in 1914 that the condition was brought on by the second metatarsal's overlength. Idiopathic metatarsal head osteochondrosis is known as Freiberg disease. The disease's symptoms, which include discomfort, swelling from synovitis, and limited movement, have a detrimental impact on the patients' day-to-day activities (1-3).

After Sever disease of the calcaneus, Panner disease of the capitellum, and Kohler disease of the tarsal navicular, Freiberg's disease is the fourth most prevalent osteochondrosis (4).

In addition to anti-inflammatory medications used in the early stages of Freiberg illness, conservative treatment options include the application of a pad to the metatarsals or the use of a rehabilitation splint to lower the pressure in the metatarsal head (5).

Surgery has been established as a therapy option for circumstances where conservative measures would not be sufficient or successful. When it comes to these options, debridement, retrograde drilling, core decompression, subchondral autograft (such as removal of the proximal phalanges' articular surface or the metatarsal head), osteochondral tissue implantation, osteotomies, and joint replacements are the most often used options (6-8).

Closing-wedge osteotomy is a commonly used therapeutic method with positive outcomes, while no single modality has emerged as the gold standard (9). Kinnard and Lirette originally identified dorsal closing-wedge osteotomy in 1979, and they had good outcomes with the same procedure in 1991 (10).

Many publications have endorsed the two types of closure wedge osteotomies: extra-articular and intra-articular. Less secure fixation from the little, intact section of the metatarsal head and avascular necrosis may be drawbacks in intra-articular osteotomy. Extraarticular closing-wedge osteotomy, when compared to intra-articular osteotomy, offers the advantage of a more secure fixation at the usual metaphyseal osteotomy site, despite concerns regarding excessive elevation of the metatarsal head (9).

There have been several reported techniques for correcting osteotomy sites. Circlage wire was

employed in the study by Gauthier and Elbaz Katcherian (2) to secure the osteotomy site; nevertheless, tendonitis developed in the extensor tendon, necessitating the removal of the wire. Although Kinnard utilized an absorbable suture, it is said that these sutures are not strong enough to be fixed. For fixation, Chao Kiatoka (11) employed a temporal cross-pinning of Kirschner wire (K-wire) (7). Simple steps are involved in using this method, but it cannot be used to perform early range of motion (ROM) training and requires the removal of metal objects (12).

Usually, the dorsal aspect of the second metatarsal head is where Freiberg disease is detected. Behind the second toe, it manifests as a painful bony knuckle (13). It usually affects girls more than boys during adolescence (M: F ratio = 1:5). All metatarsal heads are susceptible to osteochondrosis; 27% of cases occur in the third and 3% in the fourth (3, 4).

6.6% of patients had bilateral involvement. Although the precise cause is still unknown, it is generally agreed that there is a complex etiology involving trauma, reduced vascularity, genetic disorders, and altered biomechanics (14).

Orthoses, metatarsal bars, and activity modification are used in the conservative treatment of early-stage patients (5). When non-invasive methods fail to alleviate the symptoms, surgery is taken into consideration. Joint arthroplasty, drilling, metatarsal osteotomies (7-9), joint debridement, elevation of depressed articular fragment, and bone grafting are among the surgical techniques (10).

The current study aims to assess the functional recovery and pain relief with dorsal closings wedge osteotomy in conjunction with debridement application in cases of Freiberg illness.

METHODS

This prospective cohort study was carried out at Zagazig University's Faculty of Medicine's Orthopedic Surgery Department. Twelve of the individuals included in the analysis had chronic, severe pain that interfered with walking and other everyday activities and that did not get better after three months of nonsurgical treatment. The study excluded patients with pre-existing second toe deformities (malunion, hallux valgus deformity), medical co-morbid diseases that preclude surgical intervention, and history of toe pathology or surgery (tumor, infection, etc.).

The study was approved by ethical committee of Faculty of Medicine, Zagazig University (IRB number 9034-26-10-2021)

The following was applied to each patient

Taking a complete history.

Comprehensive clinical assessment.

Imaging modalities include X-rays, A-P, lateral, and oblique views and CT scans, which can detect early stages of subchondral sclerosis. Flattening of the MT head involved. destruction together in advanced illness. Usually, the upper portion of the MT head's articular surface is where the deficiency is found.

Operative Technique

The patient was placed in a supine position and had the procedure under regional anesthetic. They used a tourniquet. On the metatarsophalangeal joint's midline, a dorsal incision was made. Lateral retractions of the extensor tendons occurred. A debrided joint was used to remove any loose bodies and hypertrophic synovium. The articular surface lesion was removed, and depending on the magnitude of the lesion, a dorsal closure wedge osteotomy over the distal normal metaphysis with adequate bone removal followed. In order to bring the healthy plantar portion of the metatarsal head into articulation with the proximal phalanx, the metatarsal head was twisted dorsally and proximally. Two tiny (1.5mm) K wires were used to secure the osteotomy site. A single thick (2.5 mm) K-wire or other fixation techniques, such as sutures, were used to fix some rotationally stable osteotomies. Soft tissue was then released by cutting the extensor digitorum brevis tendon and lengthening the extensor digitorum longus tendon using Z plasty, and the skin incision was closed.

Postoperative care

For two weeks, the foot was kept immobile in a walking cast with a short leg and frequent dressings until the stitches were taken out. After four weeks, there will be a weekly x-ray until the osteotomy union, and then a monthly x-ray until the end of six months. Running and other intense activity were to be avoided for up to eight weeks, and soft shoes were recommended.

A visual analogue scale (VAS) was employed to evaluate the degree of pain alleviation or exacerbation (15).

Postoperative assessment

Patients were evaluated radiologically (anteroposterior, lateral, and oblique foot x-rays) for joint status and healing of the osteotomy site, and clinically using a lesser metatarsophalangeal interphalangeal (LMPI) scale developed by Kitaoka et al. (11). The final examination was conducted after six months.

Statistical Analysis

SPSS was used for data collection, tabulation, and statistical analysis (IBM SPSS Statistics, Version 23.0 for Windows. Armonk, New York: IBM Corp). The mean ± SD and (range) were used to represent quantitative data, whereas (percentage) was used to convey qualitative data. When comparing paired or non-normally distributed variables, the Wilcoxon sign rank test was employed. Pairings of ordinal variables were compared using the marginal homogeneity test. Every test had two sides to it. A p-value of less than 0.05 was deemed statistically significant, whereas a p-value of more than 0.05 was deemed statistically insignificant. For qualitative variables, the data were presented as numbers and percentages, and for quantitative variables, as mean + standard deviation (SD).

RESULTS

12 patients, ages ranging from 18-45, with a mean age of 31±8.7 years, were included in the study. Right foot involvement affects 58.3% of cases. In the left foot, however 41.7%. The second metatarsal affected (91.7%) patients, and the third metatarsal affected one patient 8.3%. X- ray staging of studied patients was distributed as 33.3%, 41.7%, and 25% at stage III, IV and stage V, respectively. Operation time ranged from 60-110, with a mean of 76.3±16.5 minute (Table 1). Seven cases had excellent final score results, two cases had good score, two cases had fair score and one case had poor score (Table 2). Regarding the study group's problems following extra-articular dorsal closure wedge osteotomy surgery; one patient (8.3%) had intraoperative bone fragment. Regarding post-operative complication, only one patient suffered from post-operative superficial infection and improved on oral antibiotics after five days. All patients represented with decreased range of 11° flexion mainly and some 5° extension (Figure 1).

The mean ± SD of the Pre-operative pain score was (8.67± 0.88) with a range (from 7 to 10) reduced post-operative to be (1.33±2.01) with a range (from 0-to 6), the difference was statistically significant (p= 0.002) with a percent of improvement of 85.8% (Figure 2).

Table 1: Baseline data of studied patients

Variable	**The studied group (12)**	
Age(years): **mean ± SD** **(Range)**	 31±8.7 (18-45)	
	n.(12)	**%**
Side affected Right Left	 7 5	 58.3% 41.7%
Affected metatarsal *Second* *Third*	 11 1	 91.7% 8.3%
Pre-op. X-ray staging Stage III Stage IV Stage V	 4 5 3	 33.3 41.7 25.0
Operation time (minute): mean ± SD (Range)	 76.3±16.5 60-110	
Bone union(weeks): mean ± SD (Range)	 5±1.3 6-8	

Table 2: Final score results

Cases	Grade of pain
Seven cases	Excellent
Two cases	Good
Two cases	Fair
One cases	Poor

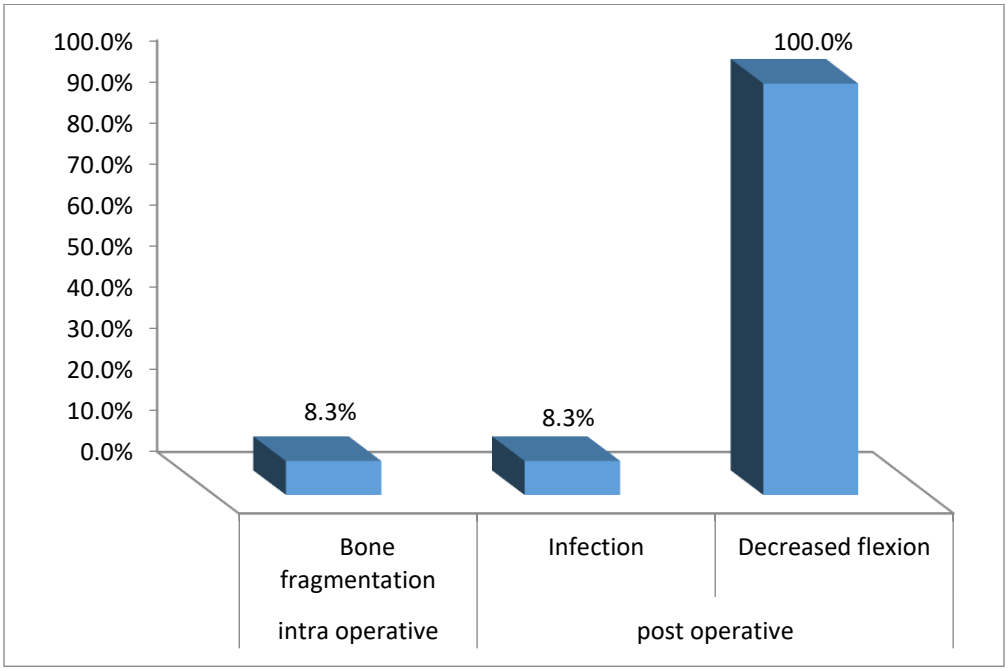

Figure 1: Percent of complications of extra-articular dorsal closing wedge osteotomy surgery intraoperative and post-operative among the studied group

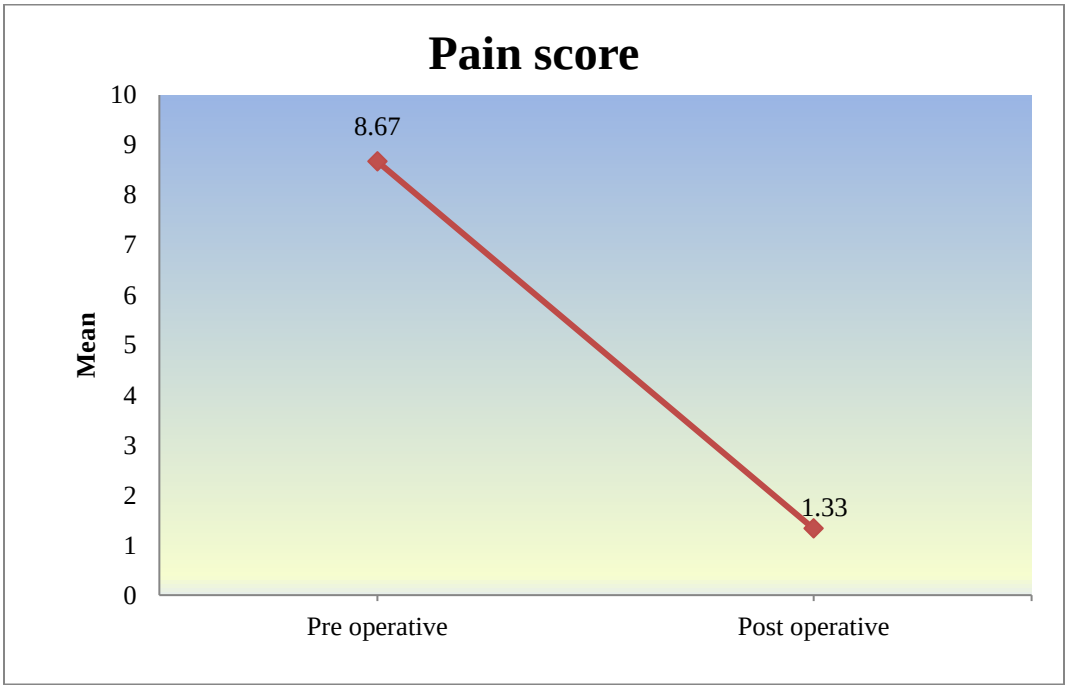

Figure 2: Mean of pain score pre- and post-operative

DISCUSSION

The dorsal aspect of the second metatarsal head is typically affected by Freibergs disease (16). A painful bony knuckle behind the second toe is how it initially appears. It usually affects girls more than boys during adolescence (M: F ratio = 1:5). All metatarsal heads are susceptible to osteochondrosis; 27% of cases occur in the third and 3% in the fourth (3,4). 6.6% of patients experience bilateral involvement. Although the precise cause is still unknown, it is generally agreed that there is a complex etiology involving trauma, reduced vascularity, genetic disorders, and altered biomechanics (17).

The aim of this research was to enhance the results for individuals suffering from Freiberg sickness. To assess the early results of debridement application combined with dorsal close wedge osteotomy for Freiberg disease in terms of pain alleviation and functional recovery (18).

The mean ± SD of the Pre-operative pain score was (8.67± 0.88) with a range (from 7 to 10) reduced post-operative to be (1.33±2.01) with a range (from 0-to 6), the difference statistically significant p= 0.002 with Percent of improvement (85.8%).

There was an average of 2.1 mm of metatarsal shortening and an average of 8° of extension and 15° of flexion reduction in passive range of motion. After undergoing a 3 mm shortening, one patient developed transfer metatarsalgia (19).

There was an average loss of 10° in extension and 15° in flexion. With no instances of transfer metatarsalgia, metatarsal shortening averaged 2.5 mm. There were no serious complications mentioned. In our research, as demonstrated by Bruno Lambert et al. (21) and Pereira et al. (22), who studied 53 patients who underwent dorsiflexion osteotomy and identified just one patient with persisting pain, Stages III and IV showed a larger improvement in scores in the Kitaoka et al., (11) scoring system.

Thirteen patients in all phases of Freiberg's illness receiving dorsal closure wedge osteotomy had two unsatisfactory outcomes, according to Chao and Co-Workers (12).

Of the twelve patients who had dorsal wedge osteotomy treatment, Lee et al. (23) observed one delayed union.

Two patients out of the 19 who received dorsal wedge osteotomy treatment had subpar outcomes, according to Capar et al. (9). A mean reduction of 11 degrees was noted in flexion, and a mean reduction of 5 degrees in extension. However, the inability to carry out regular everyday tasks like walking or jogging has not been impacted by this loss (24).

In order to treat 15 patients of late-stage Freiberg disease, Kinnard and Lirette (25) performed intra-articular dorsal closed wedge osteotomies. According to their findings, 2.4 mm was the average amount of brachymetatarsia that was seen after surgery. In our investigation, the average post-operative brachymetatarsia was similarly 3 mm. Furthermore, the current investigation did not find evidence of floating toe or transfer metatarsalgia associated with metatarsal bone shortening. It would seem, therefore, that the degree of metatarsal bone shortening that accompanied osteotomy in our investigation was well under control (26).

There have been reported benefits and drawbacks to both intra- and extra-articular osteotomies. Due to the short distal part of healthy bone in intra-articular osteotomy, solid fixation is technically challenging. According to Lee et al. (27), intra-articular osteotomy with absorbable pins produced positive outcomes; however, one should take into account the absorbable pins' cost. Additionally, compared to other studies, the healing period is lengthy and requires a similar amount of cast immobilization.

These disadvantages do not apply to extra-articular osteotomy. Technical challenges still exist, though, and soft tissue striping is unavoidable. This could impede bone healing or result in more aseptic necrosis (28).

K-wires were inserted at the specified angle that we replicated in our investigation with the use of fluoroscopic guidance. They served as a sawing guide. K-wires were used to sustain the osteotomy following the removal of the bone wafer, which greatly facilitated cross-pinning without requiring significant soft tissue stripping. We were able to establish stable fixation and early bone healing, which made the MTP joint's early range of motion feasible.

This method yields good outcomes, and most of the time, the issues are caused by the usage of osteosyntesis material. The advancement of percutaneous surgery has made it possible to conduct this wedge osteotomy with a smaller incision, hence lowering morbidity. Additionally, the process is repeatable, and hardware removal in an outpatient department is made possible by the use of a K-wire (18).

Helix-Giordanino et al. (29) looked at 30 patients, the average age of whom was 61.2 years, and found that 27 of the patients had damage to the second metatarsal and 3 cases to the third metatarsal. Two

dorsal staples were utilized to repair these individuals after they underwent a Gauthier osteotomy operation. At 15 days, 45 days, and 3 months, patients were summoned for control to gauge their level of satisfaction. The metatarsophalangeal range of motion (ROM), ossification, roundness of the metatarsal head, AOFAS score, and metatarsal shortness variables were assessed. A good clinical outcome was obtained with Gauthier's osteotomy technique.

Sixteen patients with Freiberg disease (five males and eleven females) were studied by Çiloğlu et al. (30). The physical examination was followed by the evaluation of their articular surfaces utilizing magnetic resonance imaging and direct roentgenogram. In order to preserve the metatarsal's length and lessen discomfort, they undertook a dorsal closed wedge osteotomy in conjunction with joint debridement.

In a study by Ikoma et al. (26), extra-articular dorsal closed wedge osteotomy was performed using a polyblend suture on 13 feet of 13 individuals with Freiberg's disease, whose ages ranged from 13 to 72 years on average.

Kim et al. (31) examined 19 patients who underwent surgery for Freiberg's disease, with an average follow-up duration of 71.6 months (41-121 months) and an average age of 33.6 (17-62 years). They stress that one useful approach to treating Freiberg's condition is the modified Weil osteotomy.

Ten female patients, ages 14 to 24, who underwent debridement, synovectomy, dorsal closure wedge osteotomy, and pin fixation were investigated by Al-Ashhab et al. (32), where the average age was 18.3. Patients with a history of trauma and non-recovery from non-surgical treatment were also included in this study, along with those with the primary complaints of pain during sports, daily activities, and walking. The results showed that, irrespective of the disease's stage, wedge osteotomy of the metatarsal head is a good and dependable technique.

In our study, to my mind this is the first technique to combine bony and soft tissue release in expensive of limitation of movement mainly flexion and some extension.

In addition, we emphasize the need to extend the extensor digitorum brevis and tenotomy the extensor digitorum longus tendon in order to lessen the strain on the metatarsophalangeal joint.

CONCLUSION

Good outcomes in Freiberg's disease can be achieved with dorsal closure wedge osteotomy of the metatarsal neck, assisted by synovectomy, comprehensive lesion debridement, cutting of the extensor digitorum brevis tendon, and lengthening of the extensor digitorum longus tendon with Z plasty. Adequate stability is provided by fixing the osteotomy site with K-wires. The metatarsophalangeal joint is brought back into congruity by a thorough debridement procedure. The results are excellent, the surgical approach is straightforward, less expensive, and there are few operating problems.

Conflict of interest

The authors declared that they have no conflicts of interest with respect to authorship and/or publication of this article.

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