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The Effect of Opening-Wedge High Tibial Osteotomy on the Posterior Tibial Slope Assessed by Three Different Evaluation Methods

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Abstract

Background: Recently, opening-wedge high tibial osteotomy (HTO) has attracted much interest due to its advantages over closing-wedge HTO. However, it has been reported to influence the posterior tibial slope (PTS), potentiating the knee for subsequent complications.

Objectives: This study aimed at evaluating: 1. How open-wedge HTO changes the PTS, and 2. how the PTS evaluation method influences the extent of the PTS change.

Methods: Patients with genu varum deformity, who underwent HTO at the center of the current study were included. Tomofix plate or Podo plate with or without bone graft were used for fixation purposes. The pre- and post-operative assessment of the PTS was performed using three different evaluation methods, including tibial anatomical axis (TAA), fibular anatomical axis (FAA) and posterior tibial cortex (PTC).

Results: A total of 119 knees from 83 patients, with mean age of 31.32 $\pm$ 10.1 years and mean follow-up of 3.1 $\pm$ 1.9 years, were included in this study. Medial compartmental osteoarthritis was the most frequent type of etiology. The pre-operative PTS was 13.16, 13.81 and 11.55 using the TAA, FAA and PTC method, respectively. The post-operative PTS was 12.59, 12.95 and 10.77 using the TAA, FAA and PTC method, respectively. The change of PTS was not statistically significant using either methods.

Conclusions: A negligible reduction of less than 1° was observed in the PTS of patients following opening-wedge HTO. The PTS assessment was not affected by the choice of evaluation method.

Keywords: High Tibial Osteotomy, Opening-Wedge, Posterior Tibial Slope

1. Background

Since the nineteenth century, high tibial osteotomy (HTO) has been successfully applied for the management of certain major knee deformities of young patients. Although its application in knee osteoarthritis is more recent, many studies have revealed the good long-term results of HTO in these patients, giving rise to a postponed total knee arthroplasty (TKA) (1, 2).

In spite of its value in the management of knee deformities, HTO is considered as a risk factor for the modification of tibial slope, which may cause early failure or technical problems during later total knee arthroplasty (3, 4). Increased tibial slope has also been associated with anterior cruciate ligament (ACL) injury in many investigations (5, 6).

Recently, opening-wedge HTO has attracted much interest due to its advantages over closing-wedge HTO, including not violating the proximal tibiofibular joint, no alteration in the length of fibular collateral ligament and providing the opportunity for a precise intraoperative correction. However, it is also reported to increase the posterior tibial slope (PTS) more than closing-wedge HTO (7). Thus, several investigations have aimed at evaluating the change of PTS following opening- and closing-wedge HTO. Even so, there is still no consensus regarding the impact of either technique on PTS. While some studies have reported a greater change of PTS following opening-wedge HTO, others have not noticed a difference between opening- and closing-wedge HTO (8).

2. Objectives

The main objective of this study was to determine the change of PTS, following proximal tibial opening-wedge

osteotomy, through three different measurement methods. The goal was to determine the following: 1. does the open-wedge HTO change the PTS, and 2. how significant does the PTS evaluation method impact the extent of PTS change.

3. Methods

The patients, who were referred to the center of the current study with genu varum deformity and underwent single open wedge medial HTO, with or without the use of bone graft and fixed with Tomofix plate or Podo plate, were included in this retrospective study. Patients with intra-articular fracture, repeated osteotomies or a history of associated ligament procedures, were excluded from the study.

It is important to preserve the tibial slope. Thus, the anterior tibial gap was made equal to half of the posteromedial gap in all cases, to prevent inadvertent enhancement of PTS. This point was also considered during different kinds of fixation.

The major etiologies of the deformity consisted of primary knee osteoarthritis, osteoarthritis secondary to ligament instability, posttraumatic osteoarthritis and other causes, such as osteonecrosis and osteochondritis.

The clinical and demographic characteristics of the patients were obtained from medical records. The radiographic assessment of the PTS was performed on lateral X-ray images of the knee before the surgery and at the last follow-up, using three different methods, including tibial anatomical axis (TAA) (Figure 1A), fibular anatomical axis (FAA) (Figure 1B) and posterior tibial cortex (PTC) (Figure 1C). The authors used true lateral knee X-ray images that visualized at least the proximal third of the tibia.

This study was approved by the review board of the center of the current study. Besides, informed consent was obtained from patients to use their medical data.

3.1. Statistical Analysis

Descriptive variables were demonstrated as mean and standard deviation (SD). Paired t-test was used to compare the average pre- and post-operative PTS using different evaluation techniques. The statistical analysis of the mean difference of three PTS evaluation methods was used employing the analysis of covariance (ANCOVA) test. All statistical analyses were done using the SPSS for Windows, version 16. A P value of less than 0.05 was regarded statistically significant.

4. Results

In this study, a total of 119 knees from 83 patients underwent HTO surgery. The mean age was 31.32 ± 10.1 years, ranging from 17 to 64 years. The mean follow-up period was 3.1 ± 1.9 years, ranging from one to five years. Osteoarthritis in the medial compartment was the most frequent type of degenerative changes in the patients. The clinical and demographic characteristics of the patients are demonstrated in Table 1.

Table 1. The Clinical and Demographic Characteristics of the Patients

Variable	Mean ± SD or No. (%)
Age (y)	31.32 ± 10.1
Follow-up (y)	3.1 ± 1.9
Gender	
Male	54 (45)
Female	65 (55)
Leg	
Right	58 (48.7)
Left	61 (51.3)
Etiology	
Primary osteoarthritis	76 (64)
Secondary osteoarthritis	31 (26)
Other causes	12 (10)

The mean post-operative PTS decreased to 0.57°, 0.96° and 0.78° using the TAA, FAA and PTC method, respectively. The mean change of PTS obtained from three different methods was not statistically significant (P = 0.21). The pre- and post-operative PTS values were assessed by three different measurement techniques demonstrated in Table 2.

Table 2. Comparison of Pre- and Post-Operative Posterior Tibial Slope Measures Using Three Different Techniques

PTS	Before the Surgery[a]	Last Follow-Up[a]	P Value
TAA	13.16 ± 5.6	12.59 ± 5.5	0.28
FAA	13.81 ± 6.2	12.95 ± 5.5	0.11
PTC	11.55 ± 6.35	10.77 ± 5.56	0.14

Abbreviations: FAA, fibular anatomical axis; PTC, posterior tibial cortex; PTS, posterior tibial slope; TAA, tibial anatomical axis.
[a]Values are expressed as mean ± SD.

5. Discussion

Alteration of tibial slope is a source of instability that may cause the progression of osteoarthritis (9, 10). Biomechanical studies have shown a positive linear correlation

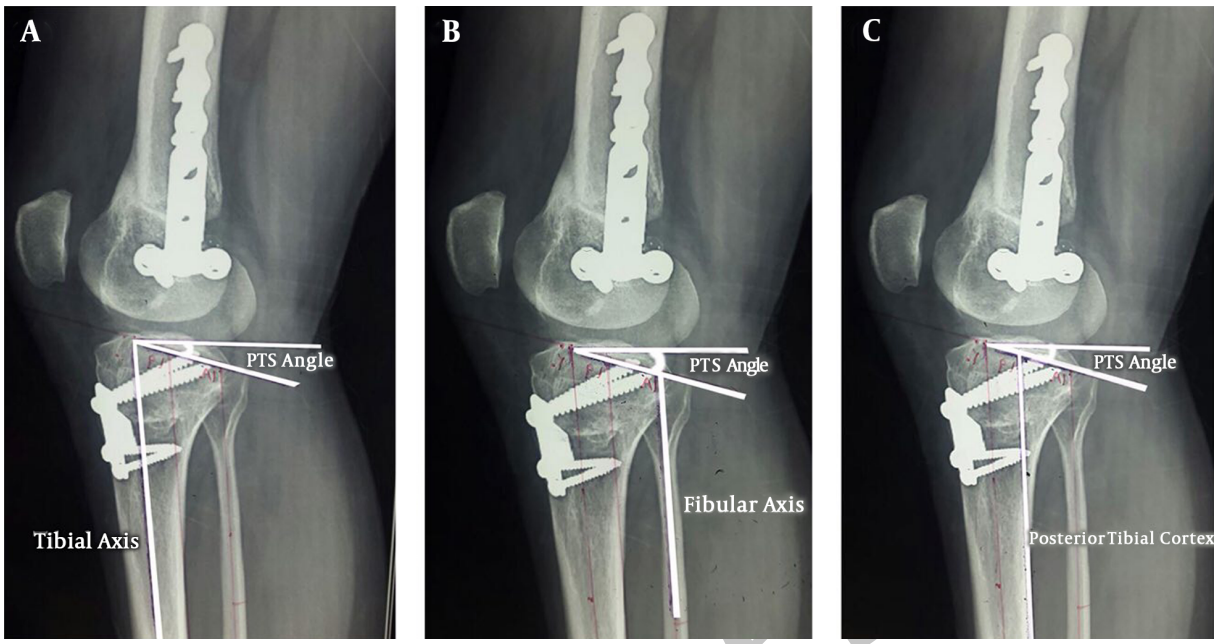

Figure 1. Radiographic assessment of the posterior tibial slope (PTS) using three different methods: A, tibial anatomical axis (TAA); B, fibular anatomical axis (FAA); and C, posterior tibial cortex (PTC).

between tibial slope and tibial translation during monopodal stance (10, 11). Moreover, Dejour and Bonnin found a very strong correlation between tibial slope and anterior tibial translation in both healthy and injured knees (12). Thus, it is important to avoid the modification of tibial slope.

Opening and closing-wedge osteotomies are the most common form of HTO. Both techniques have advantages and disadvantages and there is no consensus regarding the superiority of either of them (13, 14). Thus, several investigations have focused on this subject to finally introduce one technique as the standard of care.

Many studies have reported alterations in the PTS following opening-wedge HTO. LaPrade et al. prospectively evaluated the postoperative change in tibial slope in 129 patients (130 knees), who underwent opening-wedge proximal tibial osteotomies. According to their results, the mean tibial slope significantly increased from 9° to 11.9° at six months. They concluded that a significant increase in tibial slope could occur following opening-wedge HTO and may affect patellar height and future ligament reconstructions (15). Dragosloveanu et al. also observed a significant increase in PTS following opening-wedge HTO surgery of 47 patients at a mean follow-up of two years (16). The same results were reported in the study of El-Azab et al. that evaluated radiographs of 60 knees, who had undergone opening-wedge high tibial osteotomies. According to their results, the mean slope increased from e 5.0° to 8.1° when stabilised with a non-locking plate and from 7.7° to 9.1° when stabilised with a locking plate (17).

However, it is still unclear whether opening-wedge HTO results in considerable changes in the PTS or not. The results of previous studies are not consistent in showing that the PTS increase following the open-wedge HTO (8). Although the majority of earlier investigations showed an increase in the PTS following open-wedge HTO (8), the study of Chae et al. demonstrated a reduction in post-operative PTS, although not statistically significant. They evaluated the PTS in 32 patients, who underwent opening-wedge HTO using autologous tricortical iliac bone graft in 34 knees. At a mean follow up of three years, a non-significant reduction was observed in the posterior slope. Pre- and post-operative PTS were 8.7° and 8.2°, respectively (18). Similar to the study of Chae et al., the current researchers found a small non-significant reduction in the PTS of patients after surgery.

Since several evaluation techniques have been developed for PTS assessment, this study hypothesized that the inconsistent results of different investigations might be attributed to different evaluation techniques (19). Thus, this study measured PTS using three different methods, including TAA, FAA and PTC. The results of the three different methods confirmed each other, all showing a slight reduction of less than 1° in post-operative PTS. The same results

were reported by Brazier et al., who compared the tibial slope using six different methods. According to their report, the values of PTS observed with six methods were different yet correlated (20).

It seems that inconsistent results of different studies might be caused by other factors than the measurement technique. From the factors that might affect this evaluation, etiology of the deformity and time from surgery to imaging could be pointed out (8). Moreover, another study introduced factors that seem essential in open-wedge HTO, so as not to modify the tibial slope: release of the posterior soft-tissues and the position of the wedge during the opening-wedge procedure and then the position of the plate (19). These factors need to be taken into account when comparing the results of different investigations.

The study had some limitations, which should be pointed out. The retrospective design of this study could be regarded as the main limitation of the study. Besides, matching of the patients according to their age, gender and etiology of the deformity could provide more valuable information.

5.1. Conclusion

A slight reduction of less than 1° was observed in the PTS of the patients following opening-wedge HTO, which was negligible. The PTS assessment was not affected by the choice of evaluation method. These results suggest that inconsistent findings of different studies are probably caused by other factors, such as technical heterogeneity and should be considered when comparing their results.

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