Assessment of Posterior Slope of Tibial Plateau in upper Tibial, MCL Sparing Open-Wedge Osteotomy in Genu Varum

Abstract

Background: Genu varum is a type of knee deformity, where lower limb mechanical axis, moves medial to the knee center. One of the best techniques for genu varum correction is high tibial osteotomy that may change some of the indices like posterior tibial slope (PTS), and Insall-Salvati patellar index (ISI).

Methods: Our study was a cross-sectional study performed on patients with genu varum before and after step cut osteotomy of upper tibia. The posterior tibia slopes before and after the high tibia osteotomy by step Cut-MCL sparing method was measured by a simple radiographic image in true lateral view. The P-Value <0.05 was considered significant.

Results: In this study 21 patients (11 male and 10 female) were enrolled. Mean age was 36.19 ± 10.17 years. Mean PTS pre operation was 11.48 ± 1.94 degrees and post operation was 11.48 ± 2.15 degrees. PTS increased after HTO and this increase was not statistically differences between men and women. In addition, this increase did not have significant relationship with age and BMI. The Insall-Salvati index showed no significant difference before and after the treatment.

Conclusion: Open-wedge tibial valgus osteotomy in Step-cut MCL sparing does not change the Tibial Slope or Insall-Salvati index.

Keywords: Genu Varum, Osteotomy, Tibia

Received: 7 months before printing; Accepted: 2 months before printing

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Introduction

Genu varum is a knee deformity where the mechanical axis of the lower limb moves toward the center of the knee. In this deformity, the mechanical axis typically shifts toward the medial part of the knee joint, causing a bow-legged appearance. In some patients, genu varum leads to cartilage damage and degenerative disorders in the internal compartment of the knee joint over the long term [(1)]. Due to increased force on the inner portion, osteoarthritis becomes a common clinical finding in genu varum, persisting for extended durations. Treatment for genu varum is conducted across all age groups based on the severity and location of the deformity [(2-4)]. One of the most effective treatments for correcting genu varum is proximal tibial osteotomy, particularly performed in young patients suffering from early-onset osteoarthritis and degenerative changes in the knee joint, especially in the inner compartment with varus deformities resulting in genu varum [(5)]. The primary factor in selecting patients for osteotomy is muscular strength and adequate motivation for rehabilitation program execution. The principle behind correcting genu varum is to shift the load to a relatively normal part of the knee to alleviate symptoms and prevent disease progression. Studies have shown significantly varied outcomes of proximal tibia osteotomy in different patient populations, with a consensus that this method

alleviates pain and improves muscular function in approximately 80 to 90 percent of patients within 5 years and 50 to 65 percent within 10 years [5, 6].

Awareness of potential changes, their extent, and quality in adjacent joints and their biomechanics post-surgery can serve as a guideline for orthopaedic surgeons to consider the entire body as a unit and become cognizant of the advantages and disadvantages of this procedure, its side effects, and its effects on other joints and their biomechanics [7-8]. Knee stability is primarily established by ligamentous structures, with bony components playing a less role in this regard [9, 10]. One of the bony structures contributing to knee stability is the posterior tibial slope (PTS) [11, 12], which aids in the tensioning of anterior and posterior cruciate ligaments [13-15]. The tibial slope is an angle formed by the intersection of a line parallel to the posterior slope and a line parallel to the tibial axis. Dejour and Bonnin measured the relationship between the posterior tibial slope (PTS) and increased anterior tibial translation, stating that for every 10-degree increase in PTS, there exists a direct and positive relationship with increased tibial translation [16]. The significance of PTS has been investigated in various aspects, including an increased risk of anterior cruciate ligament (ACL) rupture, while based on our knowledge; this is the first study examining PTS in proximal tibial osteotomy using the MCL sparing technique in patients undergoing HTO treatment.

Methods

Our study is a cross-sectional investigation. Inclusion criteria comprised patients suffering from genu varum, experiencing severe pain and disability due to osteoarthritis hindering normal functioning, evidence of osteoarthritis resulting from varus in the medial compartment on radiographic assessment, cooperative patients willing to participate in post-operative rehabilitation programs, and exit criteria including age over 60, BMI over 33, lateral compartment joint cartilage destruction, flexion contracture exceeding 15 degrees, and range of motion (ROM) less than 100 degrees. Based on these inclusion criteria, 17 patients with 21 affected limbs were enrolled in the study. Patients' demographic information was collected through interviews and their medical records.

A uniform surgical technique involving proximal tibial osteotomy and fixation with screws and plates was employed for all patients. In this study, we utilized the superior tibial osteotomy method using the MCL sparing technique for correcting genu varum deformities. The primary goal of this approach was to correct deformities while preserving the limb's natural length.

Step Cut - MCL Sparing Technique

With an anteromedial approach, the skin and subcutaneous tissue are opened distally from the knee joint line. The locations of the semitendinosus and gracilis tendons are identified with a fingertip, followed by the superior and inferior aponeuroses being dissected. The posterior half of the inner cortex and the posterior cortex of the tibia are cut using a stryker saw from the distal portion toward the site of attachment of the posterior MCL, thereby preserving the posterior part of the MCL during this osteotomy. Then, longitudinally, only the inner cortex of the tibia is cut from under the gastrocnemius flap towards the proximal and distal under the tibial tuberosity. The front half of the inner cortex is then cut towards the tibial tuberosity. The lateral osteotomy is completed by introducing a wedge and fracturing the lateral cortex. The correction amount is determined by inserting a needle at the site of the posterior osteotomy (distal). Using a wire cutter piece, pulled from the ASIS towards the tibial axis, the correction degree is determined, and a plate (anatomical or buttress) with three cancellous screws in the proximal and three or four cortical screws in the distal part of the plate is fixed accordingly (Figure 1).

Posterior Tibial Slope

The method for assessing the posterior tibial slope involved obtaining a simple lateral view radiograph of the upper tibia before and after

the Step Cut - MCL sparing procedure in patients with genu varum. The knee radiograph was positioned so that the femoral condyles were perfectly aligned. Subsequently, a tangent line was drawn on the superior tibial joint surface, and another line was drawn along the axis of the posterior tibial bone with a line perpendicular to it. The angle between the perpendicular line and the tangent line on the superior tibial joint surface was considered as the posterior tibial slope (Figure 2). All measurements were performed by an orthopedic surgery resident.
The ratio of the patellar tendon length to the length of the patella is termed the Insall-Salvati ratio, which is likely the most common measurement for determining patellar height. Abnormalities in the tibial tuberosity (such as Osgood-Schlatter disease, osteotomy) can influence this ratio, and if these abnormalities exist, alternative techniques might be necessary [17, 18]. The normal range for this ratio is between 0.8 to 1.2.

Statistical Analysis

The data were assessed for normality. If the data were normal, parametric tests were utilized; if not, non-parametric tests were employed. In this study, we used paired sample t-tests, Wilcoxon, Spearman, and Mann-Whitney statistical tests for data analysis. A significance level of $P < 0.05$ was considered for all analyses.

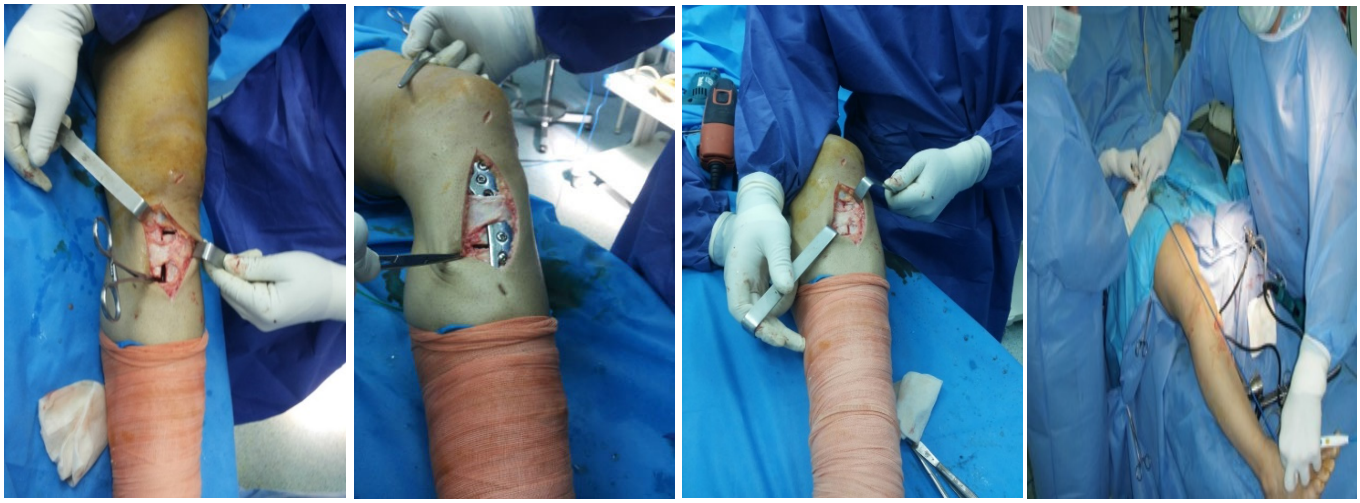

Figure 1: Step cut HTO

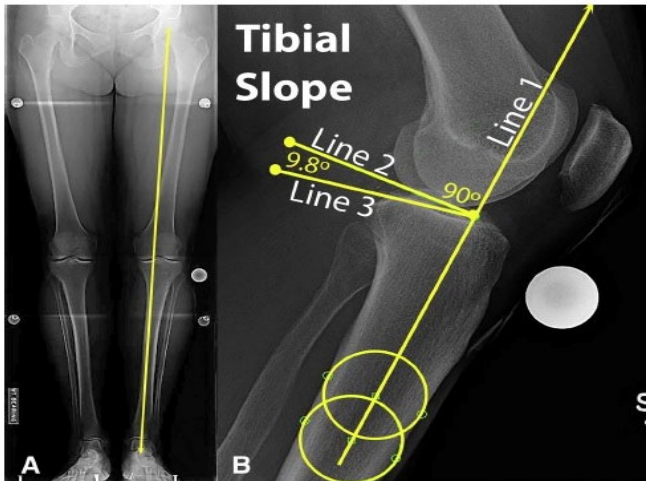

Figure 2: Measurement of Tibial Posterior Slope

Results

In this cross-sectional study, 21 patients, comprising 11 males and 10 females, with a mean age of 36.19 ± 10.17 years, participated. The results of the Kolmogorov-Smirnov test indicated that at a significant level of P < 0.05, two variables, mLDFA (medial proximal tibial angle) and preoperative slope, had a normal distribution, while other variables had a non-normal distribution. Therefore, both parametric and non-parametric tests were utilized for comparisons between variables.

Comparison of mean scores before and after surgery was conducted. The results of the statistical analysis tests, considering the significance level of P value < 0.05, showed that the mean scores of two variables, Slope and Insall, before and after the surgery, did not demonstrate a statistically significant difference (Table 1).

In other words, the surgical intervention did not significantly impact the increase or decrease in the values of these variables.

The results of the non-parametric Mann-Whitney statistical analysis, considering the significance level of P value < 0.05, indicated that the Slope variable had a p-value of 0.368, which was greater than the significance level of 0.05. Hence, no statistically significant difference in the amount of Slope changes after surgery between males and females was observed. Similarly, the Insall variable also had a p-value of 0.82, which was greater than the significance level of 0.05. Therefore, no statistically significant difference between males and females was observed in the mean value of this variable after surgery (Table 2).

The analysis of the relationship between variables using the Spearman statistical test at a significance level of P-value < 0.05 indicated that the correlation between Delta-Slope and age had a P-value of 0.185, which was greater than the significance level of 0.05. Therefore, it can be stated that the changes in Insall are not affected by age and have similarly occurred across all age groups. Similarly, for the BMI variable, the results showed a p-value of 0.78. Consequently, BMI has no effect on the slope after surgery, and the relationship between delta-slope, age, and BMI appears to be similar (Table 3).

Table 1: Demographic Characteristics and Slope Angle Specifications

	Range(min-max)	Mean± SD
Age	21-55	36.19 ± 10.17
BMI	19.1-32.1	25.83± 3.58
mLDFA(degree)	80-92	89 ±2.64
Slope_Pre OP(degree)	8-15	11.48 ± 1.94
Slope_Post OP(degree)	8.3-17	11.52 ± 2.15
Insall-Salvati _ratio_pre	0.7-1.2	0.92 ± 0.13
Insall-Salvati _ratio_post	0.6-1.1	0.90 ± 0.13
MPTA Pre OP(degree)	77-82	81 ± 1.24
MPTA Post OP(degree)	87-89	88.2 ± 0.23

Table 2: Relationship between Delta-Insall Ratio, Delta-Slope, and Gender

		N	Mean Rank	P-value
Delta_Insull	Female	11	10.73	0.829
	Male	10	11.30	
	Negative Ranks	7[a]	10.07	0.895
	Positive Ranks	9[b]	7.28	
Delta_Slop	Female	11	9.86	0.368
	Male	10	12.25	
	Negative Ranks	9[d]	10.17	0.466
	Positive Ranks	8[e]	7.69	

Discussion

The optimal treatment for young and middle-aged active patients suffering from progressive and symptomatic patellofemoral involvement and mild to moderate osteoarthritis causing a reduction in load transmitted to the medial compartment of the knee joint [19, 20] is to correct the genu varum, hip-knee-ankle angle, and prevent the progression of damage to the inner part of the knee joint, which is the primary goal of proximal tibial osteotomy (HTO) [19]. One of the most significant factors influencing knee joint biomechanics and cruciate ligament function is the posterior tibial slope (PTS), which we evaluated in this study [21].

In our study, we examined the Step Cut (MCL sparing) HTO in patients with symptomatic patellofemoral involvement, which, according to our knowledge and database searches, is the first research measuring changes in degrees and ratios in this method. In a study conducted in Iran on 431 individuals without a history of previous knee problems, the average PTS was 1.40 ± 3.9 degrees [22]. In another similar study involving 108 individuals in Tehran, the mean PTS was 1.8 ± 4.9 degrees, and there was no statistically significant association between age and gender with PTS [21].

The current study's results indicated that there was no statistically significant relationship between PTS and age or gender. Furthermore, the mean PTS before surgery was 11.94 ± 8.11 degrees, which was higher than the normal population.

In our study, PTS increased after HTO, and this increase did not have a statistically significant difference between men and women. Additionally, we demonstrated that this increase did not have a significant correlation with age and BMI.

In a study conducted in 2014 on cadaver models, some intraoperative factors that could influence surgical outcomes, such as the degree of PTS during HTO, were evaluated. The study results indicated that the average PTS was 9.3 ± 7.2 degrees and varied from 4 to 17 degrees [23]. In a meta-analysis comprising twenty-seven studies, the results demonstrated an average increase of 2.02 degrees (P = .005) after open-wedge HTO and a mean reduction of 3.52 degrees (P < .001) after close-wedge HTO [24].

Changes in PTS are responsible for alterations in knee joint biomechanics. Increased anterior tibial translation and anterior cruciate ligament strain result in increased PTS after open-wedge HTO. Conversely, increased posterior tibial translation and posterior cruciate ligament strain lead to a direct reduction in PTS [25], aligning with our study's findings.

In a study involving 39 women and 8 men, there was no statistically significant relationship between preoperative varus and changes in posterior tibial slope after surgery (P = 0.226), consistent with our study's results in this regard [26].

In the present study, the Insall-Salvati index did not show a statistically significant difference before and after treatment. This implies that patellar height did not undergo a significant change. Furthermore, we did not encounter any cases of patellar alta or baja in this study.

In a study conducted in 2009 on 29 patients with genu varum, examining the Insall-Salvati index (ISI), the results showed no statistically significant change in ISI [27], consistent with our study. Additionally, in our study, we demonstrated that delta IS had no correlation with age and BMI, which had not been previously investigated in any study.

Table 3: Relationship between Demographic Variables and Angle

		Age	BMI
Delta-insall	Correlation Coefficient	-0.349	-0.317
	P-value	0.121	0.161
Delta-slope	Correlation Coefficient	0.301	-0.063
	P-value	0.185	0.787

Conclusion

In this study, we investigated changes in PTS before and after surgery, as well as the Insall-Salvati index (ISI) in proximal tibial osteotomy using the Step Cut (MCL sparing) method. The results indicated that although Step Cut HTO increased the mean PTS, these findings were not statistically significant and did not show a significant correlation with age and BMI. Considering the limited scope of the study concerning the impact of HTO on patellofemoral involvement, further research in this area is recommended to provide a better evaluation of the parameters mentioned in this study.

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