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How Does the Position of the Wedge Influence the Tibial Slope After High Tibial Osteotomy?

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Abstract **Original Research Article**

Open-wedge high tibial osteotomy often results in an increase in the tibial slope. Factors responsible for this increase are not clearly defined. The purpose of this study is to assess the influence of the position of the wedge on the changes of the tibial slope. This monocentric retrospective study included 87 patients with symptomatic isolated medial osteoarthritis of the knee. All patients were operated with open-wedge high tibial osteotomy with locked plate fixation. Tibial slope was measured on lateral x-ray of the tibia referring to posterior tibial cortex. The position of the wedge was estimated by measuring the distance between the posterior tibial cortex and the posterior lower part of the wedge. Measurements were performed by the same observer using Carestream® software. Data were analyzed with the SPSS 20 statistical software. Mean tibial slope was 6,03° preoperatively and 5,98° postoperatively with a non-significant decrease of 0,05°. Mean distance between the wedge and the posterior tibial cortex was 9,02mm, there was a significant correlation between this distance and the change in tibial slope ($p<0,001$) ($R=0,73$). However, there was no significant correlation between preoperative varus, degree of correction, age or BMI and changes in tibial slope. So, we recommend, during open-wedge high tibial osteotomy, to place the wedge in the posterior part of the osteotomy to avoid an increase in tibial slope and ensure better knee function.

Keywords: high tibial osteotomy, open-wedge, tibial slope, position of the wedge.

INTRODUCTION

Open-wedge high tibial osteotomy (HTO) is an efficient and widespread technique in the treatment of medial osteoarthritis of the knee with varus deformity especially in young patients [1, 2]. Time saved with this procedure ranges from 6 to 15 years before prosthetic surgery [3, 4]. Several techniques have been described for valgus HTO, the two main ones are opening- and closing-wedge osteotomies. The first technique has the advantage of being precise and without risk to the fibular nerve [5]. However, many studies report an increase in the posterior tibial slope angle after open-wedge HTO [6, 7]. But most of these studies have used standard plate and were not interested in the factors that influence the variations of the tibial slope. The aim of our study was to analyze changes in tibial slope angle immediately after open-wedge high tibial osteotomy with locked plate fixation and to assess the influence of the position of the wedge on these changes.

MATERIAL AND METHODS

This monocentric retrospective study included patients aged less than 72 years, with varus deformity and symptomatic isolated medial osteoarthritis of the knee, regardless of the weight and the degree of varus. It excluded patients with trauma or ligamentous instability or osteonecrosis of medial compartment. Finally, 87 patients were selected: 64.4% female, mean age was 58 ± 6 years range (42-72 years), and mean BMI was 29 ±

5 kg / m². All patients were operated in the same hospital by open-wedge HTO with locked plate fixation.

Surgical Technique

The surgical technique was the same in all patients: after anteromedial longitudinal skin incision, the sartorius, gracilis, semitendinosus tendons, and the distal portion of the superficial medial collateral ligament are exposed and deattached from their insertion on the proximal tibia. Then a guide pin is inserted under fluoroscopic control, 3-4 cm below the joint line in an oblique direction toward the lateral tibial cortex just at the level of the proximal tibiofibular joint (Figure 1).

Figure 1: Fluoroscopic control of the direction of the guide pin

The osteotomy is performed with osteotome above the insertion of the patellar tendon. Maximum attention was given to keep the lateral cortex intact. Then the osteotomy is opened by putting the operated member into forced valgus. After the test wedges, the final wedge is inserted at the posterior part of the medial opening. Finally, a locked plate is placed in the medial cortex of the proximal tibia (Figure 2).

Figure 2: Locked plate placed in the medial cortex of proximal tibia

Radiographic Measurements:

Posterior tibial slope was measured in all patients, preoperatively and at second day postoperative, on lateral x-ray of the upper 2/3 of the tibia according to Brazier and al method [8], referring to posterior tibial cortex: The posterior tibial slope angle is equal to the angle formed by the tangent to the medial tibial plateau and the posterior tibial cortex axis, minus 90° (Figure 3).

Figure 3: The tibial slope, 9,55° in this case

The position of the wedge was estimated by measuring the distance between posterior tibial cortex and posterior lower part of the wedge (Figure 4). All measurements were performed, by the same observer using Carestream® software.

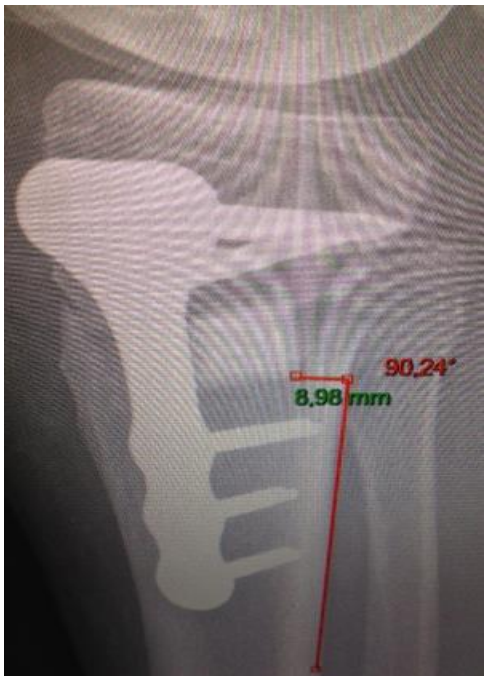

Figure 4: The position of the wedge, 8,98 mm in this case

Statistical Analysis

Data were analyzed with the SPSS 20 statistical software program. Paired sample t-test was used to analyze changes in the tibial slope angle before and after osteotomy, and independent samples t-test was used to compare means of distance between the group of patients with increased tibial slope and the group with declined tibial slope after osteotomy. Pearson correlation coefficient was used to search for a correlation between the change in tibial slope on one hand, and the position of the wedge, preoperative varus, degree of correction, age and BMI on the other hand. Correlations were evaluated using the Pearson's correlation coefficient test. A p <0.05 was considered statistically significant.

RESULTS

Mean tibial slope was 6,03±3,31° preoperatively and 5,98±4,16° postoperatively with a non-significant decrease of 0,05° (p>0,05). Mean distance between the wedge and the posterior tibial cortex was 9,02±4,24mm, there was a positive correlation statistically significant between this distance and the change in tibial slope (difference between postoperative tibial slope and preoperative tibial slope) (p<0,001) : an increase in the distance between the wedge and the posterior tibial cortex ; wedge placed in anterior, leads to an increase in the difference between the postoperative and preoperative tibial slope and consequently to an increase in postoperative tibial slope (correlation coefficient R = 0.73). In fact, an increase in tibial slope angle was observed in 36 patients (41%) it averaged 1.89 ± 1.58 °, the mean distance between the wedge and the posterior tibial cortex in this group of patients was 12.04 ± 3,19mm. while a decrease in tibial slope was observed in 37 patients (42%), it averaged 1.98 ± 1.47 °, the mean distance between the wedge and the posterior tibial cortex in this group of patients was 6.24 ± 3,68mm. This difference of 5,79 mm between the means of wedge-posterior tibial cortex distance in the 2 groups of patients is statistically significant (p<0.001). To note, a third patient group n = 14 (17%) retained the same tibial slope, the mean distance between the wedge and the posterior tibial cortex in this group was 8.85 ± 2.5 mm. Furthermore, HKA angle (Hip-Knee-Ankle) went from a mean of 174.67 ± 2.80° preoperatively to a mean of 183.77 ± 2.49° postoperatively, with a mean increase of 9.10 ± 3.5°. This degree of correction is statistically significant but with no correlation with tibial slope variations. Similarly, no correlation was found between the change in the tibial slope and the value of preoperative varus, age or BMI (Table 1).

Table 1: Correlation between the variation of the tibial slope and the age, the BMI, the preoperative varum, the degree of correction and the position of the wedge

	Tibial slope variation	
	Pearson Correlation Coefficient (R)	**Signification (p)**
Age	-0,15	0,16
BMI	-0,19	0,28
Preoperative Varum	-0,51	0,64
Degree of correction	-0,6	0,57
Position of the wedge	**0,74**	**<0.001**

BMI: Body Mass Index

DISCUSSION

This study looked at the influence of the position of the wedge on changes in tibial slope after open-wedge HTO. The most important finding is that tibial slope increased if the wedge is placed in the anterior part of the osteotomy. Another important finding is that globally with our surgical technique the tibial slope remains unchanged after the open wedge HTO.

These results are interesting, they come from a study with many patients N=87, operated by the same team, with a same surgical technique, using the same materials. All the measurements were made by the same observer using software that gives enough precisions. However, some weak points must be noted and encourage us to interpret these results with caution, the retrospective and non-comparative nature of the study, and the absence of long-term follow-up of changes in the tibial slope.

In literature, several studies were interested in the change of the tibial slope after open wedge HTO, but they did not consider the influence of the position of the wedge on these changes; Marti *et al*., [9] recommend a complete osteotomy of the posterior cortex and adequate release of the posterior soft tissue. Wang *et al*., [10] report that open-wedge high tibial osteotomy using the lateral location as a cortical hinge affects the changes of posterior tibial slope less than using the posterolateral location as a cortical hinge. Noyes and al. in their study [11] suggest that the posteromedial opening gap of the osteotomy should be 2 times larger than the anterior opening gap to maintain the posterior slope. But even if these methods are used, the tibial slope increased with 2 to 4 degrees [6, 7, 12-15]. In our study an increase in tibial slope was observed only in 36 patients (41%) it was less than 2°. In our opinion this may be explained by the surgical technique which placed the wedge in the posterior part of the osteotomy and used a locked plate.

The posterior tibial slope is important for the correct knee function. The changes in the posterior tibial slope during open-wedge high tibial osteotomy may influence the knee kinematics and stability [16-18], and result in surgical difficulties at a later revision by total knee arthroplasty [5, 19-21]. If we consider the results of this study, we must place the wedge in the posterior part of the osteotomy and use a locked plate to avoid a greater change in the tibial slope. But prospective and comparative studies, with a long follow up, are needed to confirm these finding.

CONCLUSION

In the present study, using a system of locked plates, only the position of the wedge influenced the change in the tibial slope postoperatively. So, it's recommended to place the wedge in the posterior part of the osteotomy and to use locked plates for fixation, to reduce changes in tibial slope, ensure better knee function and better conditions for revision by total knee arthroplasty.

Competing Interests: Authors declared they have no conflict of interest.

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