The Effect of High Tibial Osteotomy on the Posterior Tibial Slope

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ABSTRACT

Introduction: High tibial osteotomy remains a useful procedure for delaying total knee arthroplasty for young patients with unicompartmental medial osteoarthritis of the knee. The tibial posterior slope is essential for both ligament function and knee kinematics. Even though many articles were published in the literature, the long term influence of open wedge high tibial osteotomy on the posterior slope of the tibial plateau remains unknown.

Objective: We assessed the relationship among the degree of correction, the surgical technique, the postoperative modification of tibial slope, knee flexion and Knee score at the two years.

Material and methods: We used for evaluation a calibrated x-rays with correction factor. All the measures were done with Cedara I-View 6.3.2 application. All 47 patients were operated in our hospital between 2008-2011, with the same technique, open wedge high tibial osteotomy with an acrylic cement wedge. All patients postponed weight bearing for 6 weeks.

Results: We found that there is no statistical significance (p=0.2) between the preoperative varus and the after surgery tibial slope, but the resulting posterior inclination after surgery influences the tibial posterior slope at 2 years (p<=0.005). The degree of correction has a strong influence over the increase or decrease of tibial posterior slope(p<0.005). An increase in tibial slope increases the knee flexion by 1.45° for every degree of inclination (p<0.05). Functional results are not influenced by small modifications in tibial inclination (p>0.05).

Conclusion: From this findings we may conclude that the most important factors that changes the posterior inclination of the tibia surface are the height of the cement wedge and the surgical technique, by placing the acrylic cement wedge more anteriorly. We have found that the vast majority of our high tibial osteotomies are in fact “flexion” osteotomies. At the 2 years control we have found a slight increase in tibial slope angle (average 1.77°) and knee flexion (average 2.56°) with no functional response. This is a case series study with level of evidence IV.

Keywords: gonarthrosis, high tibial osteotomy, tibial slope

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INTRODUCTION

High tibial osteotomy has been established as an efficient surgical intervention for young patients with unicompartamental osteoarthritis of the knee. Even though this type of procedure is used for many years and many articles were published in the literature, the effect of high tibial osteotomy on the posterior slope after 2 years is unknown. It is already accepted that this procedure is only a method for delaying the total knee arthroplasty (1-4). The good results come from choosing a good candidate, a young patient, preferably under 60 years of age, with good range of motion, with osteoarthritis only in the medial compartment, with a normal lateral compartment, without knee instability and with a BMI under 30.

In this study we plan to analyze the influence of open wedge high tibial osteotomy on the tibial posterior slope immediately after surgery and at 2 years. Tibial posterior inclination is very important for the future function of the knee ligaments and in general for knee kinematics.

MATERIALS AND METHODS

From 2008 to 2011, forty-seven knees were diagnosed with unicompartamental osteoarthritis of the knee and were proposed for open wedge high tibial osteotomy with acrylic bone cement as bone substitute. The study group included 39 women and 8 men. The mean age of the group was 57.5 ± 8.4 years (range between thirty to seventy years). We do not consider age an exact preoperative surgery indication for open-wedge high tibial osteotomy; biological age and patient ability to recover or loose weight are more important from our point of view.

None of the patients had a history of other diseases or severe trauma involving the knee. None of the patients had any sort of knee instability and they all had a clinically knee flexion of 90° or more. All our patients had pre-surgery axis deviation of the pelvic member to varus. The follow-up was exactly 2 years ± one week with x-rays control immediately postop, at 6 weeks and then at 2 years. Knee Society Score was used for evaluation at 2 years control. Knee flexion was measured before surgery and at 2 years period and changes were recorded. The 2 years follow-up period was chosen due to the fact that we wanted for our patients included in the study to have the same time period after the intervention so we can objectively measure their outcome and knee biomechanical changes at the requested time.

All patients had their x-rays calibrated and all the exposures were obtained with the same Siemens Machine. The posterior slope was calculated using Cedara I-View 6.3.2. The tibial slope is measured on the lateral x-ray with a long view of the tibial shaft. A tangent is marked in Cedara between anterior and posterior borders of the tibial plateau. The angle between this line and the anatomical axis of the tibia minus 90° is the tibial posterior slope (5, 6) (Figure 1).

The data obtained was analyzed with SPSS 20.0.0.

Preoperative planning

The preoperative planning was made on standard frontal x-ray calibrated and using Cedara I-View 6.3.2. The degree of varus deformity was measured preoperatively as the femorotibial angle (7,8). The degree of correction was decided preoperatory using the Miniaci planning technique. We always prefer an over-correction to around 5° (9) of valgus and the weight distributed predominantly in the lateral compartment (3). In some cases this is not obtainable due to the need of a large correction, over 10-15°.

The osteotomy gap opening (in mm) depends on the mediolateral width of the osteotomy (in mm) and the planned correction angle. For sizing the opening gap we used the trigonometric chart by Hernigou (10) and the preoperative determined osteotomy site length (Figure 1).

Surgical Technique

The surgical technique is extremely important for the functional outcome of the future osteotomy also for the future and inevitable total knee arthroplasty. From our experience open wedge high tibial osteotomy is able to delay the knee arthroplasty usually for 10 years. Even if, in literature some authors stated a delayed arthroplasty for 20 years after closing edge tibial osteotomy, we were unable to obtain such successful results (2,12).

Placing the acrylic cement distractor more anterior will greatly increase the tibial sloping,
while a medial to posterior position will decrease the posterior inclination of the tibia.

We always use the tourniquet and we make a 5 cm incision over the pes anserinus insertion halfway between the medial border of the patellar ligament and the posterior margin of the tibial. We expose the tibia subperiosteally and plan the osteotomy above the tibial tubercle. We protect the patellar tendon and the posterior neurovascular bundle with retractors.

The starting point of the osteotomy is around 3.5 cm below the joint line. We use a chisel and fluoroscopic imaging to make the starting point for the osteotomy. If the bone is soft we make the osteotomy cut with the chisel within 1 cm of the lateral cortex of the tibial. In the case the bone is hard we use the electric saw. We find the chisel to be easily to control.

The acrylic cement piece is precut in the required shape and size. We apply valgus stress on the knee to make room for the cement distractor and insert it in the osteotomy gap by hand or hammered in a postero-medial direction.

We use a T plate for fixation with two 6.5 mm cancellous screws and three 4.5 mm cortical screws distally. The T plate is placed subperiosteally in a sliding motion first distal and then proximal through the small incision. We close the wound in layers and we do not use drainage. The leg is placed in a brace with no weightbearing for 6 weeks (11-14).

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**RESULTS**

All patients had signs of tibial bone consolidation at 6 weeks after surgery with no complication. No infections were observed. They obtained an increase in valgus deviation by 8.75° from a preoperative mean varus deviation of 5.719° (standard deviation 2.0933) to a postoperative mean valgus of 3.03° (standard deviation 2.9879). This result has a statistical significance t(46)=3.745, p<0.005. Five patients had a residual varus deviation. Among this patients, one had a 9.8° residual varus from a 14.4° preoperative, varus and was considered a failure probably, due to unstable fixation and a tight MCL (15) (Figure 2).

We noticed an increase in tibial posterior slope by 1.23° from a mean preoperative posterior slope of 7.98° (standard deviation 1.874) to an after surgery mean of 9.22° (standard deviation 2.352). This result is statistically significant t(46)=3.389, p<0.005.

The two years control showed a decrease in valgus correction by 1.64° from a mean postoperative value of 3.03° (standard deviation 2.9879) to a mean 2 years control value of 1.4° (standard deviation 2.7043) with statistical correlation t(46)=19.073, p<0.005.

The tibial slopping has also changed by 0.53° to a mean value of 9.75° (standard deviation 2.0406). t(46)=4.120, p<0.005. A total of 1.77° increase in tibial slope was noted at 2 years control.
There is no statistical correlation between the preoperative varus and the changes posterior tibial slope after surgery, \((t(46)=-1.228, p=0.226)\), but it is a strong statistical relation between the postoperative valgus and its influence on a posterior tibial slope immediately after surgery and at 2 years, \((p<0.005)\). This means that not the initial varus, but the degree of correction obtained has a strong influence in the increase of posterior tibial slope (Figure 3).

We measured the position of the cement wedge in relation with the midline of the tibial shaft and found an average of 1.3 mm of anterior displacement. The position of the osteotomy in sagittal plane is very important. A slight increase in in posterior angulation of the osteotomy gap will greatly increase the tibial slope.

The two years control had some interesting findings. An increase in knee flexion was noted (average increase 2.567°, std. deviation 3.249) from a preoperative mean value of 111.808° to an after surgery mean value of 114.375°. This increase is statistically correlated with the increase in posterior tibial slope (average increase 1.77°, std. deviation 2.241) \((p<0.05)\).

Average Knee Society Score at 2 years was 88.76 (std. deviation 4.602) and is not statistically linked to the increase in tibial slope \((p=0.453)\) (Table 1). We gained an increase in KSS score of 16.32 at 2.5 years compared to preoperative evaluation.

**DISCUSSION**

The tibial posterior slope is extremely important for knee flexion, for the correct function of the cruciate ligaments and the normal knee kinematics in general. The physiologic range of slope of the tibial plateau is between 6°-10° (16-19) as stated by various authors. This inclination is optimal for the normal function of the knee, for its stability and for normal movement of the tibia under the femur.

The open wedge high tibial osteotomy with an acrylic cement wedge allows for alteration of the sagittal inclination of the tibial plateau by the means of eccentric distraction of the osteotomy gap. If the osteotomy is opened anteriorly more than posteriorly (by anteriorly positioning of the wedge), the tibial slope will increase. If opened posteriorly more, the slope decreases (we call it an extension osteotomy).

The question that we put was what happens if we don’t want an extension or flexion osteotomy, but instead we want to preserve the physiologic tibial inclination? From our data we can see that the vast majority of osteotomies that we performed were in fact “flexion” osteotomies, probably due to the fact that is easier to place the cement wedge medial or an-

<table>
<thead>
<tr>
<th>Preop. slope</th>
<th>Postop. slope</th>
<th>2 years slope</th>
<th>Degree of correction</th>
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</thead>
<tbody>
<tr>
<td>8.0</td>
<td>9.2</td>
<td>9.8</td>
<td>8.7</td>
</tr>
<tr>
<td>Mean varus</td>
<td>Postop. valgus</td>
<td>2 years valgus</td>
<td>Age</td>
</tr>
<tr>
<td>5.7</td>
<td>3.0</td>
<td>1.4</td>
<td>57.49</td>
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**TABLE 1.** Table of results.
From our data we can conclude that the majority of open wedge high tibial osteotomies with acrylic bone substitute increase the tibial posterior slope by 1.23° (p<0.005). Extra-care must be applied when placing the cement wedge and also positioning the osteotomy cut in sagittal plane. Clinically this increase is irrelevant, with almost no functional consequences. At two years the posterior inclination continues to slightly increase by 0.53° (p<0.005), but still with no functional consequences. Total posterior tibial inclination was modified by a mean 1.77°. The multiplication factor for knee flexion is 1.45 for every degree of tibial slope increase.

CONCLUSIONS

We can say that the most important factors that influence the posterior tibial inclination are the surgical technique, by means of direction of the osteotomy cut in sagittal plane, the placement of the wedge in a medial to anterior position and the height of the cement wedge. Modifying the posterior tibial slope affects the normal kinematics of the knee joint and therefore it is safer not to be changed during open wedge high tibial osteotomies in the coronal plane.

The Knee Society score after two years shows excellent results after tibial osteotomy and the results are not linked to the small changes that occurred in the tibial posterior inclination.

High tibial osteotomy remains an affordable surgical procedure in the arsenal used for treating unicompartmental gonarthrosis, with excellent results, but unfortunately scarcely used (27).

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French.


