ORIGINAL ARTICLE

RADIOGRAPHIC ASSESSMENT OF THE OPENING WEDGE PROXIMAL TIBIAL OSTEOTOMY

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ABSTRACT

Objective: To radiographically evaluate individuals who underwent opening wedge proximal tibial osteotomy, with the aim of analyzing the proximal tibial slope in the frontal and sagittal planes, and the patellar height. Method: The study included 22 individuals who were operated at the National Traumatology and Orthopedics Institute (INTO) for correction of varus angular tibial deviation using the opening wedge osteotomy (OWO) technique with the Orthofix monolateral external fixator. Patients with OWO whose treatment was completed between January 2000 and December 2006 were analyzed. The measurement technique consisted of using anteroposterior radiographs with loading and lateral views with the operated knees flexed at 30°. Results: There were no statistically significant differences between the pre and postoperative tibial slope and patellar height values in the patients evaluated. Conclusion: Opening wedge proximal tibial osteotomy is a technique that avoids the problems presented by high proximal tibial osteotomy, since it is done without causing changes to the extensor mechanism, ligament imbalance or distortions in the proximal tibia.

Keywords – *Osteotomy; Osteoarthritis; Tibia/radiography*

INTRODUCTION

Osteotomy on the proximal tibia to treat osteoarthrosis of the medial compartment of the knee postpones the need for arthroplasty[1]. Realignment of the lower limbs has been the subject of an extensive debate within orthopedic practice. Tibial osteotomy to correct varus deviation in the frontal plane is one of the most common procedures, and it can be differentiated into two types in relation to the time of correction: immediate and gradual.

Several authors have advocated the advantages of each of these two techniques, and the anteroposterior tibial slope and patellar height have been among the characteristics studied[2]. Changes to the values of these parameters modify the biomechanics of the knee and sometimes lead to unsatisfactory results and increase the technical difficulty in patients who are going to undergo total knee arthroplasty. Thus, in view of this demand, with the need to minimize structural alterations in the light of future surgery, techniques such as the one described by Turi *et al*[3] have emerged. Their technique promotes hemicallotasis through gradual medial opening by means of an external fixator. According to Magyar *et al*[4,5], the clinical complication rate with this technique is lower than with immediate-correction osteotomy. The mean duration of hospitalization and the mean time taken for complete recovery are shorter[4-7] with gradual-opening osteotomy than with immediate correction (respectively, on average, 1.4-5 days versus 3-5 months).

The scarcity of literature on this morphometric characteristic among the Brazilian population makes it important to have greater detailing on the real incidence of these factors.

Several authors[2,8-10] have described the importance of using radiography for evaluating arthrotic knees and for managing certain abnormalities that are found, with the aim of improving the results.

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A variety of factors have been debated as causes of unsatisfactory results from high osteotomy of the proximal tibia, including changes to the patellar height (low patella and high patella) and changes to the proximal tibial slope in the sagittal plane.

The most appropriate technique would be the one that brought together the lowest rate of abnormalities in these factors, and osteotomy with gradual opening ("opening wedge osteotomy") of the tibia is a technique that may include these prerequisites, thereby giving rise to lower demand for subsequent arthroplasty.

Our objective in this study was to radiographically evaluate individuals who underwent opening wedge osteotomy, with the aim of analyzing the proximal tibial slope in the frontal and sagittal planes, and the patellar height, and to investigate the incidence of abnormalities in the anteroposterior slope of the proximal tibia and in the patellar height, among the population undergoing opening wedge osteotomy on the proximal tibia.

METHODS

This study included individuals who underwent operations at the National Traumatology and Orthopedics Institute (INTO) to correct varus angular deviation of the tibia by means of the technique of opening wedge osteotomy (OWO) using an Orthofix monolateral external fixator. Individuals with previous fractures in the lower limbs, inflammatory arthritis, soft-tissue lesions at the level of the extensor mechanism or previous surgery on the extensor mechanism (proximal and distal realignment) were excluded. In this study, 22 patients who underwent OWO and whose treatment was completed between January 2000 and December 2006 were analyzed.

The radiographs evaluated were from patients who underwent hemicallotasis as described by Turi *et al*[3]. The procedure was carried out under fluoroscopic control and external fixators (Orthofix) were used. The incision to perform hemicallotasis was made in the proximal anteromedial region of the tibia, at the level of the tibial tuberosity, and was around 3 cm in length. In cases of greater deformity (> 15º) fibulectomy needed to be performed in order to protect the fibular nerve and the proximal tibiofibular joint. All the patients were allowed to move the knee through the range of motion, as tolerated, on the day after the operation. After a latency period, distraction was started at a speed of 1 mm/day (divided into four times 0.25 mm per day). The external fixator was locked when the right correction was reached, as shown on radiographs, and was removed when callus formation and consolidation were shown.

The following data were obtained retrospectively and recorded in a specific file: age, sex, weight, height, patellar height (length of the patellar tendon), Insall and Salvati index[10] (relationship between patellar tendon length and the major axis of the patella), Caton index (relationship between the distance from the tangent of the tibial plateau to the lower edge of the patellar joint surface and the length of the patellar joint surface), Blackburne and Peel index[9] (relationship between the distance from the lower extremity of the patellar joint surface to the anterior edge of the tibial plateau and the length of the patellar joint surface), Moore and Harvey method[11] (angle between the perpendicular to the line tangential to the tibial crest and the line tangential to the joint surface of the tibial plateau) and anteroposterior slope[12] measured through the posterior cortical bone. These data on the patients were obtained by analyzing the records in the medical files and the radiographs in the medical archives.

The measurement technique consisted of using anteroposterior radiographs with loading and lateral views with the operated knees flexed at 30°. Evaluations were made by a physician (CB) under supervision by a member of the medical staff (RR)[13].

This study was approved by the Research Ethics Committee of the National Traumatology and Orthopedics Institute (INTO) and was developed among cases referred by the Knee Surgery and External Fixator services of this institution.

The results were correlated and statistically analyzed using SPSS 13.0. Firstly, central trend and dispersion measurements were produced for the variables obtained. Subsequently, because of the numerical paired variables, intraclass correlations were used to observe correlations from before to after the operation, among the indices described.

RESULTS

Among the 22 patients in this study (Table 1), seven were females (31.8%) and 15 were males (68.2%). The mean age was 44.14 years (standard deviation 12.16 and median 45.5 years). The mean height was 1.68 m (standard deviation 0.09 and median 1.68 m) and the mean weight was 76.5 kg (standard deviation 15.4 and median 74.5 kg). No intra-articular fractures were found in the

Table 1 – Patellar height values before and after the operation

Medical file	Age	Sex	Side	Patellar height	Patellar height after the operation
121048	52	M	L	55	50
125066	43	F	R	45	50
140141	59	M	R	56	50
147071	49	M	R	60	50
11964	54	M	L	45	43
145517	54	M	R	42	45
133015	42	M	L	47	48
133749	17	M	L	47	39
137363	31	F	R	27	27
123980	54	F	R	48	49
144061	39	M	R	62	57
135606	48	F	L	42	40
114845	37	M	L	57	47
129614	56	M	R	39	42
103640	49	F	R	53	54
130852	36	M	L	29	36
142110	40	M	L	52	52
99709	42	M	L	60	61
149125	57	F	L	45	45
146254	41	M	R	65	60
101209	14	F	L	55	52
130564	57	M	L	60	45

Source: INTO Hospital

cases evaluated. Regarding the side operated, 10 were right knees (45.5%) and 12 were left knees (54.5%).

Before the operation, the mean patellar height was 49.59 mm (standard deviation 10.07 and median 50 mm) and the means for the indices were: Insall and Salvati 1.16 (standard deviation 0.22 and median 1.17), Blackburne and Peel 0.98 (standard deviation 0.19 and median 1.0) and Caton 0.90 (standard deviation 0.17 and median 0.93). The mean slope angle of the tibial plateau was 10.14° (standard deviation 6.065 and median 8.0).

After the operation, the mean patellar height was 47.36 mm (standard deviation 7.83 and median 48.5) and the means for the indices were: Insall and Salvati 1.11 (standard deviation 0.19 and median 1.10), Blackburne and Peel 0.92 (standard deviation 0.13 and median 0.94) and Caton 0.87 (standard deviation 0.11 and median 0.86). The slope angle of the tibial plateau was 10.73° (standard deviation 6.281 and median 10.0).

The intraclass correlation coefficient found (Table 2) was: 0.903 for patellar height ($p < 0.001$), 0.880 for Insall and Salvati ($p < 0.001$), 0.575 for Blackburne and Peel ($p = 0.028$), 0.306 for Caton and Deschamps ($p = 0.20$) and 0.904 for the tibial slope ($p < 0.001$).

Table 2 – Normal values and mean values found for the main indices

	Normal values	Preoperative mean	Postoperative mean	p-value
Patellar height	49.59	47.36	p < 0.001*	
Insall Salvati index	0.8–1.2	1.16	1.12	p < 0.001*
Caton Deschamps index	0.6–1.2	0.90	0.87	p = 0.20**
Blackburne Peel index	0.54–1.06	0.98	0.92	p = 0.028*
Tibial slope	10.14	10.73	p < 0.001*	

* Statistically significant

**Not significant

DISCUSSION

Patients with medial arthrosis who undergo tibial osteotomy may, over the course of evolution, have the need to undergo another operation to convert this into knee arthroplasty[14]. Tibial osteotomy was found to be converted into total knee arthroplasty at rates of between 20 and 50% after ten years[15].

Some authors[14,16-18] have reported that the results from total knee arthroplasty subsequent to osteotomy have not come close to the results from primary arthroplasty.

When knee surgeons perform total knee arthroplasty after high tibial osteotomy[19,20], they may find a very "tight" joint space, ligament imbalance, a very short patellar tendon and tibial rotation and slope that are difficult to determine before the operation. Moreover, there may be previous bone losses and overcorrection. According to Closkey and Windsor[21], the unsatisfactory results from total knee arthroplasty subsequent to tibial osteotomy may be due to changes in patellar height, and the technique used for the preceding high tibial osteotomy may influence the final result from conversion to arthroplasty[22].

Bae *et al*[23] suggested that patellar eversion during the operation may be difficult because of conditions of low patella and adherences below the patella and around the osteotomy, such that either proximal procedures (such as rectus snip or VY turndown) or, more commonly, distal procedures (osteotomy of the anterior tuberosity of the tibia) become necessary.

Ligament imbalance in patients who are going to undergo total prosthetic knee replacement subsequent to high tibial osteotomy may be caused by failure of the posterior cruciate ligament. According to Akasaki *et al*[24], arthroplasty has been used to promote effective relief in cases of osteotomy failure, and they observed that the results among patients who underwent replacement of the posterior cruciate ligament were clinically superior to the results among those in whom this ligament was maintained. Thus, they suggested that prostheses with replacement of the posterior cruciate ligament should be used for patients who underwent previous tibial osteotomy.

Brouwer *et al*[25] observed that because of pain, 27 of their patients who underwent opening osteotomy (60% of the cases) had to have their implants removed (Puddu plate), as did 11 patients who underwent osteotomy closed with staples (23% of the cases), which presented a statistically significant value ($p < 0.001$). In other studies[26,27], it was observed that in patients who underwent opening wedge osteotomy, there was a reduction in the patellar height, compared with patients treated with a closure wedge. Brower *et al*[26] also found that the anteroposterior proximal tibial slope increased in the opening group and decreased in the closure group. On the other hand, Billings *et al*[27] did not find any cases of low patella in their high tibial osteotomy procedures with lateral closure, and suggested that the use of a calibrated tibial cutting system, rigid fixation and early mobilization would be the factors responsible for the result encountered.

Scuderi *et al*[2] suggested that the factors responsible for the low patella in cases of high tibial osteotomy would be: scar tissue surrounding the patellar tendon caused by immobilization, bone formation at the osteotomy site, changes to the tibial slope and elevation of the tibial plateau after high tibial osteotomy. They also observed that the incidence rate of low patella in their cases was up to 89%.

Aglietti *et al*[28] observed a varus recurrence rate of 14% of the cases that they studied (61 cases) and showed that 19% of their cases had a very low patella (Caton < 0.6). They suggested that this was mainly due to postoperative immobilization ($p = 0.04$).

Another factor that has been postulated[29], which may have an important role in causing low patella would be slope loss, thus leading to relative shortening. Chae *et al*[29] suggested that to avoid slope loss, the relationship between the anterior and posterior spaces should adhere to a ratio of 2:3. Contrary to the findings of Kaper *et al*[30], we did not find any cases of low patella or slope loss. These factors that may cause low patella were avoided with this technique. Other factors that were implicated in changes to tibial slope after high tibial osteotomy included: the slope precision of the osteotomy and a very anteriorly positioned plate, which added to the fact that the site was proximal to the insertion of the extensor mechanism. These small deviations in the technique could directly cause changes to the indices that were evaluated. Slope loss after high tibial osteotomy (closure) produces relative elevation of the posterior cruciate ligament.

Lemon *et al*[31] suggested that the presence of retropatellar fibrous tissue in cases in which complete resection of the retropatellar fat was performed in total knee arthroplasty could be the factor responsible for a low patella. However, Grelsamer *et al*[32] suggested that this was probably due to changes in the height of the joint line. They underlined the importance of using indices for patellar height assessment, like Insall and Salvati, in order to differentiate between low patella and low pseudo-patella[18], in which there is no shortening of the patellar tendon. They also warned that measurements using the Blackburne and Peel and the Caton and Deschamps indices are also abnormal in cases of low pseudo-patella[18], and thus should not be used in isolation to determine the retraction of the patellar tendon. Barnett *et al*[33] suggested that because these are indices that use a line traced out by the tibial plateau, they may lead to reduced accuracy[34-36].

In our study, we did not find any statistically significant correlation by using the Caton Deschamps index. Kesmezacar *et al*[37] affirmed that the Caton index presents abnormalities caused by deviation of proximal fragments, thus reducing its accuracy, while the patellar height and distance remained unchanged.

Nakamura *et al*[38] affirmed that the technique of opening wedge osteotomy through hemicallotasis did not promote changes to the patellar height or the anteroposterior slope of the proximal tibia, compared with patients who underwent high tibial osteotomy ($p < 0.001$), one year after the operation. They suggested that this was because the osteotomy was distal to the patellar tendon and that the positioning of the external fixator could be corrected more simply. Serial radiological follow-up would also make it possible to avoid undesirable under or overcorrection. It is fundamental for patients to understand the procedure in order to avoid complications such as early consolidation of the regenerated bone tissue[39].

According to Weale *et al*[40], there is a low complication rate with this technique, but they reported a case of chronic osteomyelitis at the fixator pins. This needs to be taken into consideration in arthroplasty conversion surgery.

Like Nakamura *et al*[38], we did not find any statistically significant differences between the pre and postoperative values for patellar height or tibial slope among the patients who underwent opening wedge osteotomy.

CONCLUSION

Several factors increase the technical difficulty in carrying out total knee arthroplasty in patients who have already undergone high tibial osteotomy. Low patella, slope changes in the sagittal plane and valgus alignment promote abnormalities of patellar excursion or tracking, difficulty in patellar eversion during the operation and distortion of the anatomy of the proximal tibia.

There were no differences between the preoperative and postoperative values for the indices of patellar height and tibial slope, among the patients evaluated.

The technique made it possible for the patellar height and tibial slope to be maintained unchanged. This is of considerable interest for patients with medial osteoarthrosis of the knee, even with large deformities (> 15º) with the need for correction of the adductor moment, in situations in which these patients are not yet eligible for total knee arthroplasty.

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