

Patellar height modification after high tibial osteotomy by either medial opening-wedge or lateral closing-wedge osteotomies

J. Amzallag · Nicolas Pujol · A. Maqdes ·
P. Beaufils · T. Judet · Y. Catonne

Received: 21 February 2012 / Accepted: 12 November 2012 / Published online: 25 November 2012
© Springer-Verlag Berlin Heidelberg 2012

Abstract

Purpose High valgus tibial osteotomy is used to treat medial femoro-tibial osteoarthritis. Changes in patellar height due to high valgus tibial osteotomy can cause technical difficulties during subsequent knee arthroplasty. The primary objective of this study was to assess the hypothesis that patellar height decreases after opening-wedge osteotomy and increases after closing-wedge osteotomy. The secondary objective was to assess whether frontal axis correction and tibial slope modification correlated with patellar height changes.

Methods A multicentre, prospective, comparative, observational, non-randomised study was conducted in consecutive patients undergoing isolated high valgus tibial osteotomy according to standard practice in each of the ten study centres. Patellar height was assessed based on the Caton-Deschamps index.

Results Of 321 included patients, 224 underwent opening-wedge and 97 closing-wedge osteotomy. Patellar height did not change significantly after closing-wedge osteotomy (1.07 ± 0.2 pre-operatively and 1.0 ± 0.19 postoperatively). Patellar height decreased significantly after opening-wedge osteotomy (from 0.98 ± 0.19 to 0.88 ± 0.21 , $p < 0.0001$, mean decrease 9 ± 22 %).

Patellar height decreased by more than 20 % in 49 (28 %) patients after opening-wedge osteotomy. The patellar height decrease after opening-wedge osteotomy correlated significantly with axis correction magnitude and tibial slope change.

Conclusion Our results support routine baseline measurement of patellar height before high valgus tibial osteotomy and posterior positioning of the opening wedge to limit the tibial slope change in patients requiring major axis correction by opening-wedge osteotomy.

Level of evidence Prospective cohort study, Level II.

Keywords Tibial osteotomy · Patellar height · Opening osteotomy · Closing osteotomy

Introduction

High valgus tibial osteotomy has been proven effective in the treatment of medial femoro-tibial osteoarthritis [6, 9, 12]. In most studies, patellar height increased after closing-wedge osteotomy and decreased after opening-wedge osteotomy [3, 5, 8, 13–15, 22]. These changes in patellar height may adversely affect functional outcomes and create technical difficulties during subsequent knee arthroplasty. However, patellar height is not usually measured before performing an osteotomy. No studies have assessed whether taking patellar height into account improves treatment decisions and patient outcomes.

The primary objective of this prospective comparative observational study in a large patient population was to compare patellar height after medial opening-wedge and lateral closing-wedge osteotomy. Our hypothesis was that patellar height decreased after OWO and increased after CWO. The secondary objective was to determine whether

Electronic supplementary material The online version of this article (doi:10.1007/s00167-012-2304-z) contains supplementary material, which is available to authorized users.

J. Amzallag (✉) · N. Pujol · A. Maqdes · P. Beaufils ·
T. Judet · Y. Catonne
Orthopaedic Department, Hôpital André Mignot,
177, rue de Versailles, 78157 Le Chesnay, France
e-mail: amzallag.julien@numericable.fr

N. Pujol
e-mail: npujol@ch-versailles.fr

frontal axis correction and tibial slope modification correlated with changes in patellar height. Such correlations would allow selection of the osteotomy type depending on preoperative patellar height and required axis correction.

Materials and methods

Patients

This prospective comparative observational study sponsored by the French Society for Orthopaedic Surgeons (SOFcot) was conducted in ten research centres* in France between January 2008 and March 2009. Opening- or closing-wedge HVTO was performed according to standard practice in each study centre: two centres performed only CWO and four only OWO, whereas the remaining four centres used both techniques with a preference for OWO in patients having more than 8° of varus malalignment. In none of the study centres was patellar height used as a criterion to choose between closing- and opening-wedge osteotomy.

Consecutive patients requiring isolated high valgus tibial osteotomy at the supra-tuberosity level were eligible for the study. A follow-up of at least 6 months was required, to permit an evaluation of anatomical results, albeit not of clinical outcomes. Exclusion criteria were complex malunion of the proximal tibia requiring an intra-articular procedure, revision osteotomy, and need for combination with a ligamentous procedure or femoral osteotomy.

Data collection

Each centre recorded the data for each patient prospectively, in an anonymised electronic file. Then, the data were entered into a single database and checked.

We collected age, gender, and body mass index (BMI); type of osteotomy, cause of osteoarthritis (primary, post-traumatic, post-ligamentoplasty, other); and pre- and postoperative mobility and the visual-analogue-scale pain score. Radiological data used for the study were medial osteoarthritis classified using Ahlbäck criteria [1], the presence of osteoarthritis in the other knee compartments, pre- and postoperative patellar heights, pre- and postoperative tibial slopes measured according to Brazier et al. [2] (Fig. 2) as detailed by Ducat et al. [7], pre- and postoperative hip-knee-ankle (HKA) angle, and degree of correction. Pre- and postoperative long-leg radiographs were used to determine the mechanical weight-bearing axis and HKA angle and pre- and postoperative knee radiographs to measure tibial slope. The HKA and tibial slope were measured to the nearest degree. A lateral knee radiograph was used to measure patellar height based on the Caton-Deschamps index [4]

obtained by dividing the distance between the inferior patellar edge and antero-superior tibial corner by the length of the patellar cartilage (Fig. 1). The percentage difference between pre- and postoperative patellar heights was computed; the value was negative when patellar height decreased and positive when it increased. The sub-population of patients ($n = 41$) with pre-operative patella baja (defined as a Caton-Deschamps index between 0.6 and 0.8) or patella infera (defined as a Caton-Deschamps index lower than 0.6) was evaluated separately.



Fig. 1 Brazier method for tibial slope calculation



Fig. 2 Caton index for the patellar height calculation

Statistical analysis

Data were analysed using Statview® software (v 5.0, SAS Institute, Cary, NC, USA). Comparisons relied on the Student-Fisher *t* test for qualitative variables and on Pearson’s coefficient of correlation and Yates’ Chi-square test for quantitative variables. Values of *p* lower than 0.05 were considered significant.

Results

Table 1 reports the main characteristics of the 321 patients, 205 males and 116 females, with a mean age of 52 ± 9 years and a mean BMI of 28 ± 5 kg/m². OWO was performed in 224 patients and CWO in 97.

There was a significant difference between the two populations (CWO and OWO) in regard to the initial axis malalignment (HKA, 173° ± 3.2° in the opening-wedge group and 175° ± 3° in the closing-wedge group, *p* < 0.000001). Patellar height was not significantly modified by CWO (Caton-Deschamps index, 1.07 ± 0.2 pre-operatively and 1.06 ± 0.19 postoperatively, n.s). In contrast, OWO was followed by a significant 9 ± 22 % decrease in patellar height (0.98 ± 0.19 pre-operatively and 0.88 ± 0.21 post-operatively, *p* < 0.0001). After opening-wedge HVTO, 28 % (*n* = 49) of patients had a greater than 20 % decrease in patellar height (Tables 2, 3).

The patellar height decrease correlated with the magnitude of axis correction (*p* = 0.015), the more extensive the opening was, the less was the patellar height. Modification in patellar height was not correlated with modification in tibial slope in the CWO group. In contrast, after OWO, the increase in posterior tibial slope correlated significantly with the decrease in patellar height (*p* < 0.005).

Of 38 patients with patella baja, 28 underwent opening- and 10 closing-wedge osteotomy. All 3 patients with

Table 1 Description of the population

	OWO	CWO	Difference	Total population
Age (year)	53.6 ± 8.6	49.7 ± 10.3	<i>p</i> = 0.0002	52 ± 9
BMI (kg/m ²)	28.6 ± 5.5	27 ± 4.4	<i>p</i> = 0.007	28 ± 5
HKA angle (°)	173.2 ± 3.2	175 ± 3	<i>p</i> = 0.000006	173.8 ± 3.2
Ahlbäck	0 : <i>n</i> = 2 I : <i>n</i> = 36 II : <i>n</i> = 109 III : <i>n</i> = 71 IV : <i>n</i> = 6	0 : <i>n</i> = 0 I : <i>n</i> = 30 II : <i>n</i> = 37 III : <i>n</i> = 27 IV : <i>n</i> = 3	n.s n.s n.s n.s n.s	0 : <i>n</i> = 2 I : <i>n</i> = 66 II : <i>n</i> = 146 III : <i>n</i> = 98 IV : <i>n</i> = 9

Table 2 Patellar height distribution

Caton index	IC ≤ 0.6	0.6 < IC < 0.8	0.8 ≤ IC ≤ 1.2	IC > 1.2	Total
OWO (<i>n</i>)	3	28	171	22	224
CWO (<i>n</i>)	0	10	68	19	97
Total (<i>n</i>)	3	38	239	41	321

Table 3 Patellar height variations depending on population

	Pre-op	Post-op	Difference (%)	
OWO	0.98 ± 0.19	0.88 ± 0.21	−9 ± 22	<i>p</i> < 0.05
CWO	1.07 ± 0.20	1.06 ± 0.19	−1 ± 6	n.s

patella infera underwent OWO. Patellar height in these 41 patients was unchanged after high valgus tibial osteotomy (Caton-Deschamps index, 0.75 ± 0.07 pre-operatively and 0.77 ± 0.07 postoperatively). Moreover, the presence of patella baja or infera did not significantly affect the overall postoperative axis correction (183.8° ± 3.6 vs. 183.9° ± 3.4 in the patients without patella baja or infera).

Discussion

The most important finding of the present study was the mean 9 % decrease in patellar height after OWO, contrasting with the absence of significant change after CWO. Our working hypothesis was that patellar height decreased after OWO and increased after CWO.

The patellar height decrease after OWO of 9 ± 22 % was consistent with earlier reports of decreases ranging from 9 to 16 % [3, 5, 8, 13–15, 21]. After CWO, patellar height remained unchanged in our study but decreased by 5 % in a study by Tigani et al. [19]. However, in keeping with our results, Song et al. [17] found that patellar height decreased after OWO and remained unchanged after CWO. A patellar height decrease has important clinical implications, as lower patellar height can generate technical difficulties and impair functional outcomes after subsequent knee arthroplasty [16, 18, 20, 21].

We used the Caton-Deschamps index to assess patellar height. A decrease in the Caton-Deschamps index can be due either to lowering of the patella or to a decreased distance between the inferior patellar edge and antero-superior tibial corner related to a change in tibial slope. The Insall-Salvati index [11] is not affected by tibial slope modifications. However, we felt the Caton-Deschamps index would be more reproducible in this multicentre study, as the patellar tendon may be difficult to assess, most notably on postoperative radiographs [8].

The patellar height decrease correlated significantly with the magnitude of axis correction in our study. In contrast,

El Amrani et al. [8] reported that opening-wedge size was not correlated with patellar lowering as assessed using the Caton-Deschamps, Insall-Salvati or Blackburne-Peel index. This difference with our study may be ascribable to the smaller sample size of only 40 patients, compared to 321 patients in our study.

The patellar height decrease after OWO correlated significantly with the increase in tibial slope. As the importance of the axis correction is not modifiable, care should be taken to minimise changes in tibial slope. Hernigou and Ma [10] advocated positioning the bone graft wedge posteriorly to avoid tibial slope changes due to OWO. We did not assess whether graft position correlated with changes in tibial slope or patellar height. In the study by Song et al. [17] showing patellar height changes similar to those in our study, the 3-year follow-up allowed an evaluation of clinical outcomes, and no difference was found between closing- and opening-wedge HVTO in terms of anterior pain or knee flexion. The 6-month follow-up in our study was too short for an assessment of clinical outcomes.

Limitations of our study include the non-randomised design with statistically significant baseline differences between the two groups for HKA, age, and BMI. In addition, OWO was used far more often than CWO (224 vs. 97 patients). The surgical procedures were not standardised; instead, each centre followed routine local procedures regarding the material and techniques. This point explains the predominance of OWO, which is consistent with current trends in France, as well as the differences in baseline HKA and axis correction, with some centres preferring OWO only when the varus malalignment angle exceeded 8°. However, our study is the largest to date comparing OWO and CWO. Other strengths include the prospective design and inclusion of consecutive patients at centres having considerable experience with HVTO. Usually, we do not measure patellar high before performing an osteotomy: only HKA angle is considered. Now, we use to measure patellar height before osteotomy, and in case of major axis correction with an OWO, we take care to open posteriorly to avoid a decrease of patellar height.

Conclusion

This prospective multicentre study in a large sample size established that patellar height decreased after OWO, by $9 \pm 22\%$, and that the decrease correlated with the magnitude of axis correction and tibial slope change. Patellar height remained unchanged after CWO. These results suggest that patellar height should be measured routinely before high valgus tibial osteotomy and, when major axis correction is required, that the opening wedge should be

positioned posteriorly to limit the change in tibial slope and therefore the decrease in patellar height.

References

- Ahlbäck S, Rydberg J (1980) X-Ray classification and examination techniques in gonarthrosis. *Lakartidningen* 77:2091–2093
- Brazier J, Migaud H, Gougeon F, Cotton A, Fontaine C (1996) Evaluation of methods for radiographic measurement of the tibial slope: a study of 83 healthy knees. *Rev Chir Orthop* 82:195–200
- Brouwer RW, Bierma-Zeinstra SM, van Koeveeringe AJ, Verhaar JA (2005) Patellar height and the inclination of the tibial plateau after high tibial osteotomy. The open versus the closed-wedge technique. *J Bone Joint Surg Br* 87:1227–1232
- Caton J (1989) Method of measuring the height of the patella. *Acta Orthop Belg* 55:385–386
- Chae DJ, Shetty GM, Lee DB, Choi HW, Han SB, Nha KW (2008) Tibial slope and patellar height after opening wedge high tibia osteotomy using autologous tricortical iliac bone graft. *Knee* 15:128–133
- Dubrana F, Lecerf G, Nguyen-Khanh JP, Menard R, Ardouin L, Gibon Y et al (2008) Tibial valgus osteotomy. *Rev Chir Orthop* 94(Suppl. 1):2–21
- Ducat A, Sariali E et al (2012) Posterior tibial slope changes after opening- and closing-wedge high tibial osteotomy: a comparative prospective multicenter study. *Orthop Traumatol Surg Res* 98(1):68–74
- El Amrani MH, Levy B, Scharnycki S, Asselineau A (2010) Patellar height relevance in opening-wedge high tibial osteotomy. *Orthop Traumatol Surg Res* 96(1):37–43
- Hernigou P (2001) A 20-year follow-up study of internal gonarthrosis after tibial valgus osteotomy. Single versus repeated osteotomy. *Rev Chir Orthop* 82:241–250
- Hernigou P, Ma W (2001) Open wedge tibial osteotomy with acrylic bone cement as bone substitute. *Knee* 8:103–110
- Insall J, Salvati E (1971) Patella position in the normal knee joint. *Radiology* 101:101–104
- Jenny JY, Tavan A, Jenny G, Kehr P (1998) Long term survival rate of tibial osteotomies for varus gonarthrosis. *Rev Chir Orthop* 84:350–357
- Kesmezacar H, Erginer R, Ogut T, Seyahi A, Babacan M, Tenekecioglu Y (2005) Evaluation of patellar height and measurement methods after valgus high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 13:539–544
- LaPrade RF, Oro FB, Ziegler CG, Wijdicks CA, Walsh MP (2010) Patellar height and tibial slope after opening wedge proximal tibial osteotomy: a prospective study. *Am J Sports Med* 38:160–170
- Ozkaya U, Kabukcuoglu Y, Parmaksizoglu AS, Yeniocak S, Ozkazanli G (2008) Changes in patellar height and tibia inclination angle following open-wedge high tibial osteotomy. *Acta Orthop Traumatol Turc* 42:265–271
- Scuderi GR, Windsor RE, Insall JN (1989) Observations on patellar height after proximal tibial osteotomy. *J Bone Joint Surg Am* 71:245–248
- Song IH, Song EK, Seo HY, Lee KB, Kim JH, Seon JK (2012) Patellofemoral alignment and anterior knee pain after closing- and opening-wedge valgus high tibial osteotomy. *Arthroscopy* 28(8):1087–1093
- Stacheli JW, Cass JR, Morrey BF (1987) Condylar total knee arthroplasty after failed proximal osteotomy. *J Bone Joint Surg Am* 69:28–31

19. Tigani D, Ferrari D, Trentani P, Barbanti-Brodano G, Trentani F (2001) Patellar height after high tibial osteotomy. *Int Orthop* 24:331–334
20. Westrich GH, Peters LE, Haas SB, Windsor RE (1998) Patellar height after high tibial osteotomy with internal fixation and early motion. *Clin Orthop* 354:169–174
21. Windsor RE, Insall JN, Vince KG (1988) Technical considerations of total knee arthroplasty after tibial osteotomy. *J Bone Joint Surg Am* 70:547–555
22. Wright JM, Heavrin B, Begg M, Sakyrd G, Sterett W (2001) Observations on patellar height following opening wedge proximal tibial osteotomy. *Am J Knee Surg* 14:163–173