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Patellar height after high tibial osteotomy

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Abstract We analysed two series of patients affected by unicompartmental arthrosis or axial malalignment of the knee treated with two different techniques of high tibial osteotomy. Forty-seven knees were treated with a closing wedge osteotomy (CWO) and 40 with an opening wedge osteotomy (OWO). The two groups were comparable with respect to age, gender and deformity. For each patient the patellar height was measured by Caton's method before surgery, and at the latest assessment (at least 1 year after operation). The correction rate for the two series was analysed to assess any possible correlation between the variation of the patellar height and the degree of correction of the knee axis. We concluded that a high tibial osteotomy modifies the patellar height and that this depends on the technique employed. Patellar 'lowering' occurred more often with OWO than with CWO and the latter also produced a high degree of patellar elevation.

Résumé Nous avons analysé deux groupes de patients souffrant d'arthrose unicompartimentale ou de déformation angulaire du genou, traités par deux différentes techniques d'ostéotomie tibiale haute: 47 cas ont été traités par une ostéotomie externe de soustraction et 40 par une ostéotomie interne d'addition. Les deux groupes étaient comparables pour la distribution de l'age, du sexe et de la déformation. La hauteur patellaire a été mesurée avant l'opération et à la dernière visite (jamais avant le délai d'un an après l'opération) selon la méthode de Caton. Nous avons évalué entre les deux différents groupes s'il y avait une corrélation de la hauteur patellaire avec la valeur de la correction de l'axe du genou. L'étude démontre que l'ostéotomie tibiale haute modifie la hauteur patellaire selon la technique chirurgicale employée. La réduction de la hauteur patellaire est plus fréquente après une ostéotomie interne d'addition. Après l'ostéotomie externe de soustraction nous avons observé un grand pourcentage d'élévation patellaire.

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Introduction

The change in patellar height produced by high tibial osteotomy depends on the surgical technique employed. An opening wedge osteotomy (OWO) with insertion of a bone graft is often associated with a shortened patellar ligament [5, 6,7], whereas a closing wedge osteotomy (CWO) is reported to produce contrasting height modifications [5, 8,10]. In this retrospective study we compared OWO with CWO techniques in order to assess the effects on patellar height.

Materials and methods

We analysed two series of patients suffering from unicompartmental osteoarthrosis or axial deformity of the knee. As shown in Table 1 the two groups were comparable.

Forty-four patients, 22 males and 22 females (47 knees), were treated with a CWO. Coventry staples were used in 31 knees and a cylinder cast was applied for 30 days after surgery. In the remaining 16 knees the 'first step' system was employed (Howmedica, Rutherford, N.J., USA) and the operated limb was immobilised in a brace for 4 weeks. Thirty-four patients, 13 males and 21 females (40 knees), were treated with OWO. A plaster cast extending from the upper thigh to the foot was used for 30 days after the osteotomy.

Patellar height was assessed by Caton's method [2]. Assessments were done before the operation and at the latest follow-up. Caton's index is determined by the ratio between the distance from the inferior tip of the patella and the antero-superior angle of the tibia (AT distance), and the patellar articular surface length (AP distance) as measured on a lateral radiograph of the knee (Fig. 1). The normal value of Caton's index is 0.96+0.134 in males, and 0.99+0.129 in females. The patella is considered low when the index is below 0.6 and high when greater than 1.3. Tables 1 and 2 summarise the degree of deformity before and after surgery, and at the last review.

Finally, the correction rate was analysed to assess any possibly correlation between the variation of the patellar height and the knee axis correction degree. According to correction the knees were divided into three groups: those with a correction lower than

Table 1 Demographic and preoperative clinical characteristics of the patients (means ± SD and min-max; *n.s.* not significant)

	CWO (*n*=47 knees)	OWO (*n*=40 knees)	*P*
Male	25	13	0.053*
Female	22	27	
Age (years)	59.1±15.0 (16–82)	63.1±7.0 (48–78)	n.s.**
Mean preoperative varus	8.30±3.60 (20–150)	8.10±3.10 (00–150)	n.s.
Caton's index	0.89±0.24 (0.35–1.57)	0.95±0.24 (0.50–1.60)	n.s.**

*Chi-square test
**Mann-Whitney *U*-test

Table 2 Postoperative characteristics of the patients (last assessment)

	CWO (*n*=47 knees)	OWO (*n*=40 knees)	*P*
Caton's index	0.94±0.24 (0.30–1.83)	0.81±0.31 (0.21–1.83)	<0.05
Entity of variation of Caton's index	0.05±0.16 (–0.33/0.43)	–0.14±0.22 (–0.75/0.33)	<0.001

Fig. 1 Radiographic lateral view of the knee. Caton's index is 0.77

10° (group A), those with correction between 10° and 15° (group B), and those with correction higher than 15° (group C). In the CWO series the distribution between the groups was 13/23/11, whereas it was 10/12/18 in the OWO series. All patients were followed for a mean of 3.6 years and the latest review was at least 1 year after surgery.

Statistical analysis The chi-square test was used to compare the distribution of categorical variables across groups and to assess whether there was a statistically significant change between the baseline (before surgery) and at final review.

Where the variable was not normally distributed either the *t*-test or the Mann-Whitney non-parametric analysis was used to test the differences between the two independent samples. The Wilcoxon test was used with two related samples to test the continuous or ordinal variables. A simple factorial analysis of variance was applied to test whether the meaning of a dependent variable was the same in the groups of knees as defined by factor variables. The *P*-values <0.05 were considered significant. Statistical analysis was performed using the SPSS Statistical Package, version 7.0.

Results

The number of knees with a low, normal or high patella before and after the osteotomy can be seen in Table 3.

In the CWO group we noted lowering of the patella in 11 knees and elevation in 27. In the 11 cases of patellar lowering the average variation was 0.12, while in the 27 cases of elevation the average value was 0.21. Among the 13 knees in group A, three showed a reduction of the patellar height, eight an elevation, while in two knees no variation had occurred. Among 23 knees in group B patellar lowering was found in six. In four knees no variation was found and in 13 there was an elevation. Among 11 knees in group C we found two with patellar lowering, three without variation and six with patellar elevation.

Table 3 Preoperative and postoperative patella height according to Caton's index (*n.s.* not significant)

	CWO (*n*=47 knees)	OWO (*n*=40 knees)	*P*
Preoperative			
Normal	38	35	n.s.*
Low	6	3	
High	3	2	
Postoperative			
Normal	40	31	n.s.*
Low	4	7	
High	3	2	

*Chi-square test

Table 4 Entity of variation of Caton's index according to degree of correction

	CWO (*n*=47 knees)	OWO (*n*=40 knees)	*P*
Correction less than 100 (group A)	0.04±0.11	–0.11±0.17	0.002
Correction between 100 and 150 (group B)	0.04±0.16	–0.13±0.23	
Correction more than 150 (group C)	0.06±0.21	–0.17±0.24	

In the OWO group patellar lowering was found in 29 knees and elevation in seven. In group A patellar lowering was found in seven, elevation in one while the remaining two remained unchanged. In group B patellar lowering was found in nine knees and three showed elevation. In group C there were 13 with lowering of the patellar height, three with elevation and in two there was no variation.

Using the OWO technique we obtained a significant reduction of the Caton's index ($P<0.0003$; Wilcoxon's test). Using the CWO technique 57% of the knees showed a patellar elevation as expressed by the Caton's index. This was however not statistically significant. When comparing knee axis correction in the two groups of patients, we found a significantly increased number ($P<0.03$) with patellar elevation in the CWO group with a knee axis correction of less than 10°. On the other hand, in the OWO group with more than 15° of knee axis correction there was a significant decrease of the Caton's index.

Discussion

Upper tibial osteotomy has become a well-established surgical procedure for the treatment of medial degenerative arthrosis of the knee [1, 3, 4, 5, 7,9]. Its aim is to shift the axial load stresses from the degenerate area of the medial compartment to another more normal area of the articular surface [3]. However, as the long-term results remain unpredictable, it is important to make a careful pre-operative assessment of patients as to who are to undergo this type of treatment [4]. In a large series of 213 knees Insall and Salvati [8] found that early good results tended to deteriorate with the passage of time. Windsor et al. [12] reported a major difficulty in exposing the proximal tibia and in everting the patella when performing an arthroplasty after failure of a previous osteotomy. The same authors found a low patella in 80% of their cases of total knee arthroplasty after proximal tibial osteotomy [12]. The effect on patellar height varies according to the surgical technique performed. In the OWO group the decrease in patellar height is constant [3, 4,5]. Goutallier et al. [6] in a mathematical study and by using moulds showed that an angular correction carried out through the technique of OWO is associated with a lateral displacement of the tibial tuberosity, which corresponds to the degree of correction. They also found a reduction in patellar height. In the CWO group the patellar lowering reported by some authors [8, 11,12] does not agree with the study by Dohin et al. [5]. He used a theoretical model to simulate the proximal shifting of the tibial tuberosity, which is produced by a valgus osteotomy. After limited lateral displacement there should be a proximal shift of the tibial tuberosity with a resulting increase in the Caton's index. Through a theoretical calculation Dohin noticed that with a correction of 10° there should be a displacement of 0.08 cm and a proximal patellar lift of 0.8 cm [5]. However, any such relationship was not found in a clinical study made on 59 knees [8, 11,12]. Other studies using the method described by Insall and Salvati [8] also revealed significant patellar lowering after tibial osteotomy [10,11]. In 1989 Scuderi et al. [11] suggested that the use of a cylinder cast after osteotomy could cause fibrosis of the patellar tendon with subsequent development of a contracture. Major scarring of this region and excessive new bone formation may also cause patellar lowering after tibial osteotomy.

The results of our study confirm the observations of patellar lowering as the result of the use of the OWO technique [3,5]. Moreover, we also saw an increase in the number of knees with patellar lowering, especially more pronounced if the knee axis correction was more than 15°. In such knees, the need to use a large bone wedge causes a narrowing between the anterior margin of the tibial articular surface and the patella [6], thus reducing Caton's index.

From the analysis of our 47 osteotomies treated with the closing wedge technique we observed patellar lowering in 23% and elevation in 57%. In neither of these groups did we observe a shift from a normal value to a pathological value according to Caton's index. In two knees normalisation of the patellar height was noticed and this was related to a low patella.

We observed a greater statistically significant patellar elevation when using the CWO technique, but only in those knees in which the post-operative correction of the knee axis was less than 10°.

High tibial osteotomy modifies the height of the patella and this depends on the technique used (Table 4). Patellar lowering is more frequent seen with an open wedge osteotomy and the insertion of a bone graft (OWO) than with a closing wedge osteotomy (CWO). In CWO we found a significant degree of patellar elevation most often associated with a knee axis correction of less than 10°. With the OWO technique, patellar lowering would become significant if the correction of the knee axis exceeded 15°.

The CWO technique can be used when there is a low patellar height as measured by Caton's index and if the estimated correction of the knee axis does not exceed 10°. The OWO technique should be used when a major correction of the knee axis is necessary as judged by the clinical condition of the knee.

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