RESEARCH ARTICLE

Medial UKA tends to increase patellar height, whereas open-wedge HTO tends to decrease patellar height

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Abstract

Background: There is no consensus on the most appropriate method to assess patellar height following medial unicompartmental arthroplasty (UKA) or open-wedge high tibial osteotomy (HTO). The purpose of this study was to evaluate the difference between pre- and post-operative patellar height in patients receiving UKA or HTO using three indices of patellar height.

Methods: The authors retrospectively analysed pre- and post-operative radiographs of 44 patients that received medial UKA (n=21) or open-wedge HTO (n=23). Pre- and post-operative radiographs were standardised between patients, including anterior-posterior, and lateral in 30° flexion images. Postoperative radiographs were obtained at 6 weeks. Patellar height was assessed according to the Insall-Salvati index, Blackburne-Peel index, and Caton-Deschamps index.

Results: Patients that received UKA (67.4±5.8 years) were significantly older than patients that received HTO (51.3±9.0 years, $p<0.001$). Preoperative patellar height was similar between patients that received UKA or HTO according to all three indices. Postoperative patellar height was similar among the two groups according to the Insall-Salvati index, but was significantly greater following UKA according to the Blackburne-Peel index (0.95±0.13 vs. 0.75±0.24, $p=0.003$) and Caton-Deschamps index (1.09±0.17 vs. 0.93±0.26, $p=0.019$). According to all three indices, UKA tended to increase patellar height, whereas HTO tended to decrease patellar height. The differences between pre- and post-operative patellar heights were however not significant, except for the Caton-Deschamps index following UKA ($p=0.043$).

Conclusion: According to all three indices, medial UKA tended to increase patellar height, whereas open-wedge HTO tended to decrease patellar height.

Keywords: Medial UKA, open-wedge HTO, patellar height, Insall-Salvati index, Blackburne-Peel index, Caton-Deschamps index

Background

Unicompartmental knee arthroplasty (UKA) and high tibial osteotomy (HTO) are established treatments for moderate medial compartment osteoarthritis of the knee [7]. UKA [14] is a procedure that resurfaces only the affected compartment, whereas HTO [28] is a procedure that preserves the affected part of the joint, but transfers the principal load of body weight from the affected compartment to the unaffected compartment. Both open- and closed-wedge HTO are common procedures with equivalent outcomes [17], although open-wedge HTO has been performed more frequently in patients with medial compartment osteoarthritis [3]. A recent meta-analysis [7] that compared UKA to open- and closed-wedge HTO revealed lower revision rates and fewer complications after UKA, superior range of motion after HTO, but no difference in clinical scores.

Despite detailed selection criteria for UKA and HTO, their effect on the patellofemoral joint remains controversial [3,19], with considerable disagreement on the magnitude of change in patellar tendon length following medial UKA [10]. Weale et al. [27] found insignificant changes in patellar tendon length, whereas Neogi et al. [20] found the contrary. Changes in patellar height after open-wedge HTO can be expected from a theoretical perspective, but in vivo measurements yield conflicting results [9,11]. Chae et al. [9] revealed a significant increase in patellar height, whereas Gaasbeek et al. [11] revealed a significant decrease in patellar height following open-wedge HTO. Comparisons between studies are further complicated due to the use of different radiographic indices for patellar height [1,19].

The position of the patella can be expressed relative to the femur, known as direct assessment, or relative to the tibia, known as indirect assessment [25]. Since direct methods are difficult to apply, indirect methods are more widely applied [21], including the Insall-Salvati [13], modified Insall-Salvati [12], Blackburne-Peel [4] and Caton-Deschamps [8] indices. There is no present consensus on the most appropriate method to assess patellar height in UKA [10] and HTO [3]. The purpose of this study was therefore to evaluate the difference between pre- and post-operative patellar height in patients receiving medial UKA or open-wedge HTO using the Insall-Salvati, Blackburne-Peel and Caton-Deschamps indices.

Materials and Methods

Cohort

The authors retrospectively analysed pre- and post-operative radiographs of 44 patients that received UKA (n=21) or open-wedge HTO (n=23) performed by the senior surgeon (PA) at one centre. All patients had provided written informed consent for the use of their data and images for research and publishing purposes, and the study was approved by the institutional review board (IRB number: CER13-021R). Indications and selection criteria for medial UKA were similar to previous published guidelines, and included non-inflammatory osteoarthritis, symptoms limited to only the medial compartment, intact anterior cruciate ligament, range of motion of >90°,

no flexion contracture >5°, and <15° frontal plane deformity [19]. Indications for open-wedge HTO were non-inflammatory osteoarthritis or osteonecrosis with associated varus malalignment, with range of motion >100°, lateral collateral ligament laxity <grade 3, and no flexion contracture >5°. Additionally, the choice of performing UKA or HTO considered patient age and activity level, with UKA considered for patients >60 years and/or reduced levels of activity, and HTO considered for patients <60 years and/or higher levels of activity [16].

UKA surgical technique

Patients received a fixed bearing medial UKA (n=12, Allegretto (Zimmer, Centrepulse, Baar, Switzerland); n=9, SIGMA HP (Depuy Synthes, GmbH, Switzerland); depending on availability at the centre), via a minimally invasive medial parapatellar approach without patellar eversion, with the knee flexed at 90° and using a tourniquet. The integrity of the anterior cruciate ligament (ACL) was evaluated after all osteophytes were removed. In varus knees, the medial collateral ligament was recessed from the tibial plateau approximately 1 to 2 cm from the joint line between the patellar tendon and the posteromedial corner of the tibia. Resection of tibial surface and removal of osteophytes facilitated visualization of the entire medial compartment. A conservative tibial cut was then made using an extramedullary guide with the diaphyseal part of the guide parallel to the anterior tibial crest, and the anteroposterior position of the guide adjusted distally aiming for a 3° tibial slope. The distal femoral condyle was then prepared using a burr to remove the articular surface and the posterior cut was made using an extramedullary femoral guide. The tissue layers were then closed, and a drain was placed.

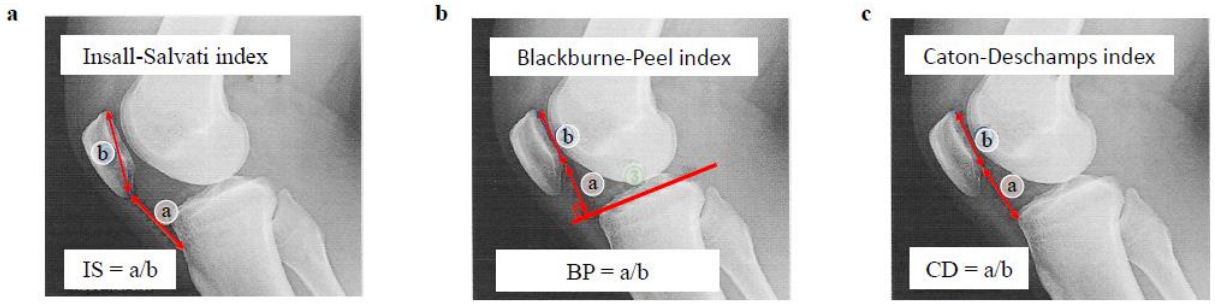
Open-wedge HTO Surgical technique

The open-wedge HTO surgical technique consisted of a biplanar 130° L-shaped osteotomy without a bone graft or bone substitute, as described by Staubli et al. [24] and Lobenhoffer et al. [18]. A longitudinal incision was made distal to the joint line, and two Kirschner-wires were inserted on the medial side to be parallel to the tibial slope, targeting the tip of the tibiofibular joint. The transverse osteotomy cut was made up to 1 cm from the lateral tibial cortex. The tibial tuberosity bone was then cut at an angle of 130°. The osteotomy was carefully opened, and the preoperatively calculated correction angle was checked using a measuring device. Internal fixation was then performed using a four-hole locked plate (n=12, Puddu plate (Arthrex Inc., Naples, FL, USA); n=11, TomoFix plate (Depuy Synthes, GmbH, Switzerland), depending on availability at the centre). The tissue layers were then closed, and a drain was placed.

Radiographic analysis

Pre- and post-operative radiographs were standardised between patients, including anterior-posterior, and lateral in 30° flexion images. Postoperative radiographs were obtained at 6 weeks. Patellar height was assessed according to the Insall-Salvati index [13], Blackburne-Peel index [4], and Caton-Deschamps index [8] (Figure 1).

Figure 1: Patellar height indices. a) Insall-Salvati index; b) Blackburne-Peel index; c) Caton-Deschamps index



Statistical analysis

Descriptive statistics were used to summarize the data. Shapiro–Wilk tests were used to assess the normality of distributions. Differences in means between continuous variables were tested using student t-tests, and associations between categorical variables were tested using Kruskal-Wallis tests. Statistical analyses were performed using R version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria). P values <0.05 were considered statistically significant.

Results

Patients that received medial UKA (67.4±5.8 years) were significantly older than patients that received open-wedge HTO (51.3±9.0 years, p<0.001) (Table 1), but there were no significant differences between the two groups in terms of sex distribution or body mass index (BMI).

Table 1: Summary of patient demographics and the pre- and popst-operative patellar heights following UKA and HTO

	UKA (n=21)		open-wedge HTO (n=22)		*p-values*		
	mean ±SD n (%)	(min – max)	mean ±SD n (%)	(min – max)	*Preop vs. Postop* *UKA*	*HTO*	*UKA vs HTO*
Patient demographics							
Age	67.4 ±5.8	(56 – 78)	51.4 ±9.2	(24 – 66)			***<0.001***
BMI	26.3 ±3.6	(21 – 34)	28.0 ±4.5	(20 – 39)			*0.190*
Women	13 (61.9%)		9 (40.9%)				*0.173*
Patellar height							
Insall-Salvati index							
Preoperative	1.00 ±0.12	(0.78 – 1.21)	0.94 ±0.17	(0.65 – 1.32)			*0.160*
Postoperative	1.01 ±0.19	(0.68 – 1.27)	0.92 ±0.29	(0.52 – 1.80)	*0.887*	*0.725*	*0.096*
Net increase	*0.01 ±0.17*	*(-0.33 – 0.38)*	*-0.03 ±0.21*	*(-0.43 – 0.48)*			*0.580*
Blackburne-Peel index							
Preoperative	0.85 ±0.21	(0.48 – 1.24)	0.86 ±0.25	(0.50 – 1.51)			*0.990*
Postoperative	0.95 ±0.13	(0.74 – 1.19)	0.75 ±0.24	(0.21 – 1.30)	*0.103*	*0.180*	***0.003***
Net increase	*0.09 ±0.23*	*(-0.41 – 0.44)*	*-0.10 ±0.24*	*(-0.48 – 0.47)*			***0.010***
Caton-Deschamps index							
Preoperative	0.97 ±0.20	(0.63 – 1.32)	1.01 ±0.22	(0.58 – 1.31)			*0.580*
Postoperative	1.09 ±0.17	(0.84 – 1.37)	0.93 ±0.26	(0.33 – 1.70)	***0.043***	*0.255*	***0.019***
Net increase	*0.12 ±0.22*	*(-0.35 – 0.54)*	*-0.08 ±0.30*	*(-0.51 – 0.97)*			***0.015***

Abbreviations: UKA, unicompartmental arthrplasty; HTO, hight tibial osteotomy; SD, standard deviation

Preoperative patellar height was similar between patients that received UKA or HTO according to all three indices (Table 1). Postoperative patellar height was also similar among the two groups according to the Insall-Salvati index, but was significantly greater following UKA according to the Blackburne-Peel index (0.95±0.13 vs. 0.75±0.24, p=0.003) and Caton-Deschamps index (1.09±0.17 vs. 0.93±0.26, p=0.019).

The net increase in patellar height was similar between patients that received UKA or HTO according to the Insall-Salvati index, but was significantly greater following UKA according to the Blackburne-Peel index (0.09±0.23 vs. -0.10±0.24, p=0.010) and Caton-Deschamps index (0.12±0.22 vs. -0.08±0.30, p=0.015). According to all three indices, UKA tended to increase patellar height, whereas HTO tended to decrease patellar height. The differences between pre- and post-operative patellar heights were however not significant, except for the Caton-Deschamps index following UKA (p=0.043).

Discussion

The main finding of this study is that, according to all three indices, medial UKA tended to increase patellar height, whereas open-wedge HTO tended to decrease patellar height. However, the only significant differences between pre- and post-operative patellar heights were detected using the Caton-Deschamps index following UKA (p=0.043). The authors would expect to observe other significant differences if the sample sizes were greater. Analysis of patellar height is of

fundamental importance for patients with patellofemoral complaints after UKA and HTO, and for this reason, there is a need for studies that evaluate differences between the indices and possible associations with clinical outcomes [2].

Unfortunately, there is still no consensus on the most appropriate patellar height indices or cut-off values [3,26]. Although the Insall–Salvati index has been found to be reliable in terms of inter- and intra-observer reliability [26], its use after HTO is inappropriate since it is related to the length of the patellar tendon, and does not refer to the joint line [17]. Conversely, Kaper et al. [15] deemed the Blackburne-Peel index unsuitable to assess patellar height after HTO, since it is influenced by the change in the inclination of the tibial plateau. Likewise, Brouwer et al. [6] considered the Caton-Deschamps index to be insufficient for patellar height measurement after HTO because it is also affected by the joint line. Finally, Bonadio et al. [5] concluded that even though there are various limitations in all patellar height indices, the most pertinent consideration for HTO is reference to the joint line, rather than patellar tendon length.

In the present study, patellar height decreased after HTO, albeit not significantly. The change in patellar height after HTO could be the result of various factors, such as patellar ligament scarring due to immobilization, change in sagittal tibial slope, as well as elevation or depression of the tibial plateau. In the meta-analysis by Lee et al. [17], the reduction in patellar height after open-wedge HTO according to the Blackburne-Peel (mean, -0.10) and Caton-Deschamps (mean: -0.08) indices were identical to those measured in the present study (-0.10 and -0.08, respectively). A decrease in patellar height could result in patella baja, which can compromise patellofemoral biomechanics, and could require subsequent total knee arthroplasty (TKA) [17]. Furthermore, revision to TKA can be challenging in knees with patella baja, though patellar eversion or patellar tendon avulsion remains straightforward if reductions in patellar height are small [3].

In the present study, the net increase in patellar height was similar between patients that received UKA or HTO according to the Insall-Salvati index, but was significantly greater following UKA according to the Blackburne-Peel index and the Caton-Deschamps index. These findings contradict previous studies [10,19,20], that reported a decrease in patellar height following UKA according to the Blackburne-Peel and Caton-Deschamps indices. The upper border of the polyethylene insert serves as reference of the tibial joint line after UKA, and is used for both the Blackburne-Peel and Caton-Deschamps index. The post-operative landmark is easier to define than the bony landmarks before surgery, and therefore, the increased Blackburne-Peel and Caton-Deschamps values may be related to the different pre- and postoperative intra-observer variability [22,23]. In the present study, UKA did not change the Insall-Salvati index, which uses the patellar tendon length as reference. Therefore, the increase in Blackburne-Peel and Caton-

Deschamps indices following UKA are likely due to a change in joint line level, rather than a change in patellar position.

This study has a number of limitations. First, this was a retrospective analysis of pre- and post-operative radiographs of 44 patients that received UKA or open-wedge HTO. Direct comparisons between the two groups are problematic due to the different indications for UKA and HTO. Second, since the cohort sizes were small, all observed trends should be interpreted with caution since the study could be underpowered. Third, this study did not consider patient reported outcome measures, and the effect of change in patellar height on clinical and functional scores could therefore not be evaluated. Fourth, patellar height measurements were only performed once by the senior surgeon, and intra- and/or inter-observer reliability could not be evaluated.

Conclusion

In the present series, according to all three indices, medial UKA tended to increase patellar height, whereas open-wedge HTO tended to decrease patellar height. The only significant differences between pre- and post-operative patellar heights were detected using the Caton-Deschamps index following UKA.

Declarations

Abbreviations: UKA, unicompartmental knee arthroplasty; HTO, Hight tibial osteotomy; ACL, anterior cruciate ligament; BMI, body mass index; TKA, total knee arthroplasty;

Ethics, consent and permissions: All patients provided informed consent for the participation in the study and the use of their data and images for research purposes. the study was approved by the institutional review board (IRB number: CER13-021R)

Availability of data and materials: Not applicable

Competing interests: The authors declare that they have no competing interests.

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Authors' contribution

PA study design, data collection and manuscript editing
JB study design, data collection
MS interpretation of findings, figures and manuscript writing
RM study design, data collectionAll authors approved the final manuscript.

References

1. Anagnostakos K, Lorbach O, Kohn D (2012) Patella baja after unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 20 (8):1456-1462.
2. Behrendt C, Zaluski A, RP EA, de Sousa EB, Cavanellas N (2016) Comparative evaluation of patellar height methods in the Brazilian population. Rev Bras Ortop 51 (1):53-57.
3. Bin SI, Kim HJ, Ahn HS, Rim DS, Lee DH (2016) Changes in Patellar Height After Opening Wedge and Closing Wedge High Tibial Osteotomy: A Meta-analysis. Arthroscopy 32 (11):2393-2400.
4. Blackburne JS, Peel TE (1977) A new method of measuring patellar height. J Bone Joint Surg Br 59 (2):241-242.
5. Bonadio MB, Torres JA, Mazzaro V, Jr., Helito CP, Gobbi RG, Demange MK (2016) PLATEAU-PATELLA ANGLE: AN OPTION FOR ASSESSING PATELLAR HEIGHT ON PROXIMAL TIBIA OSTEOTOMY. Acta Ortop Bras 24 (3):127-130.
6. Brouwer RW, Bierma-Zeinstra SM, van Koeveringe 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 (9):1227-1232.
7. Cao Z, Mai X, Wang J, Feng E, Huang Y (2018) Unicompartmental Knee Arthroplasty vs High Tibial Osteotomy for Knee Osteoarthritis: A Systematic Review and Meta-Analysis. J Arthroplasty 33 (3):952-959.
8. Caton J, Deschamps G, Chambat P (1982) Patellae inferae. Rev Chir Orthop Reparatrice Appar Mot 68 (5):317-325.
9. 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 (2):128-133.
10. Davies GS, van Duren B, Shorthose M, Roberts PG, Morley JR, Monk AP, Murray DW, Pandit HG (2016) Changes in patella tendon length over 5 years after different types of knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 24 (9):3029-3035.
11. Gaasbeek RD, Nicolaas L, Rijnberg WJ, van Loon CJ, van Kampen A (2010) Correction accuracy and collateral laxity in open versus closed wedge high tibial osteotomy. A one-year randomised controlled study. Int Orthop 34 (2):201-207.
12. Grelsamer RP, Meadows S (1992) The modified Insall-Salvati ratio for assessment of patellar height. Clin Orthop Relat Res (282):170-176.

13. Insall J, Salvati E (1971) Patella position in the normal knee joint. Radiology 101 (1):101-104.
14. Insall J, Walker P (1976) Unicondylar knee replacement. Clin Orthop Relat Res (120):83-85.
15. Kaper BP, Bourne RB, Rorabeck CH, Macdonald SJ (2001) Patellar infera after high tibial osteotomy. J Arthroplasty 16 (2):168-173.
16. Kozinn SC, Marx C, Scott RD (1989) Unicompartmental knee arthroplasty. A 4.5-6-year follow-up study with a metal-backed tibial component. J Arthroplasty 4 Suppl:S1-10.
17. Lee OS, Ahn S, Lee YS (2018) Changes of Sagittal and Axial Alignments of Patella after Open- and Closed-Wedge High-Tibial Osteotomy: A Systematic Review and Meta-Analysis. J Knee Surg 31 (7):625-634.
18. Lobenhoffer P, Agneskirchner JD (2003) Improvements in surgical technique of valgus high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc 11 (3):132-138.
19. Naal FD, Neuerburg C, von Knoch F, Salzmann GM, Kriner M, Munzinger U (2009) Patellar height before and after unicompartmental knee arthroplasty: association with early clinical outcome? Arch Orthop Trauma Surg 129 (4):541-547.
20. Neogi DS, Bae JH, Seok CW, Lim HC (2014) Impact of patellar height on unicompartment knee arthroplasty: does patella baja lead to an inferior outcome? J Orthop Traumatol 15 (1):47-54.
21. Phillips CL, Silver DA, Schranz PJ, Mandalia V (2010) The measurement of patellar height: a review of the methods of imaging. J Bone Joint Surg Br 92 (8):1045-1053.
22. Rogers BA, Thornton-Bott P, Cannon SR, Briggs TW (2006) Interobserver variation in the measurement of patellar height after total knee arthroplasty. J Bone Joint Surg Br 88 (4):484-488.
23. Seil R, Muller B, Georg T, Kohn D, Rupp S (2000) Reliability and interobserver variability in radiological patellar height ratios. Knee Surg Sports Traumatol Arthrosc 8 (4):231-236.
24. Staubli AE, De Simoni C, Babst R, Lobenhoffer P (2003) TomoFix: a new LCP-concept for open wedge osteotomy of the medial proximal tibia--early results in 92 cases. Injury 34 Suppl 2:B55-62.
25. van Duijvenbode D, Stavenuiter M, Burger B, van Dijke C, Spermon J, Hoozemans M (2016) The reliability of four widely used patellar height ratios. Int Orthop 40 (3):493-497.
26. Verhulst FV, van Sambeeck JDP, Olthuis GS, van der Ree J, Koeter S (2019) Patellar height measurements: Insall-Salvati ratio is most reliable method. Knee Surg Sports Traumatol Arthrosc 10.1007/s00167-019-05531-1.
27. Weale AE, Murray DW, Newman JH, Ackroyd CE (1999) The length

of the patellar tendon after unicompartmental and total knee replacement. J Bone Joint Surg Br 81 (5):790-795.

28. Wiley AM (1967) Reconstruction of the osteoarthritic knee by high tibial osteotomy and joint clearance. Can J Surg 10 (1):28-35.

