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ORIGINAL PAPER

Patellar height assessment in total knee arthroplasty: a new method

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Abstract
Introduction We described in 1981 a method to evaluate patellar height in normal and symptomatic knees on sagittal X-ray view. This index is a frequently used method, yet it is not suitable after a total knee arthroplasty (TKA).
Material and method The original method measures the distance between the distal margin of the articular surface of the patella (point A) and the anterosuperior angle of the tibial plateau (point T), then the length of the patellar articular surface (AP). The index is AT/AP ratio (normal values range from 0.8 to 1.2). After TKA, the T landmark is no longer available, so we must define a new T' landmark. This point is situated at the intersection between the line perpendicular to the tibial posterior cortex elevated at the tip of the fibular head and the tibial anterior cortex. This remarkable landmark can be identified before and after TKA, with a new relative index AT'/AP ratio. This modified method allows the comparison of patella height before and after TKA.
Results We have used this modified index with the collaboration of several authors during the testing of different models of TKA, with an accurate reproducibility. Repeatability (usually called intra-observer reliability) was good, with intra-class correlation coefficients (ICCs) between 0.58 and 0.75 among the observers. Reproducibility (usually called inter-observer reliability) was also considered as good, with ICC ranging from 0.64 to 0.72.
Discussion Patella height measurement has to be assessed with the original method (AT/AP) to detect patella infera that could influence the surgical approach. The correlation between original and modified indexes has to be assessed. The modification of patella height after TKA could be evaluated through the modified index and compared with functional results.

Keywords Total knee arthroplasty · Patellar height · Patella infera · Patella baja · Patella alta · Reliability

Introduction

Assessment of the patellar height is very important before and after a total knee arthroplasty (TKA).

Patella position is of great importance when considering the biomechanics of the knee. As we demonstrated in an experimental study in 1982 [1], the joint reaction force in flexion between the groove and the patella is equal to five times the body weight when load-bearing. The lower the patella, the more this force increases.

We first described [2] in 1977 and then modified [1, 3] in 1982 a method called the Caton-Deschamps index (CD) (Fig. 1) to evaluate patellar height in normal and symptomatic knees, always on sagittal X-ray view, allowing definition of patellar height (normal, alta, or infera).

Several methods have been described since Jassen in 1929 (clinical examination) and Boon-Itt [4] in 1930 (radiological method). Until 1971, only one method was used by orthopaedic surgeons: the Blumenstaat [5] technique (1938). No ratio is perfect; however, four

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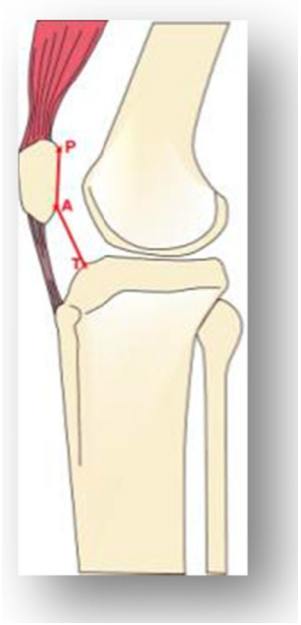

Fig. 1 Original Caton-Deschamps index (CD)

ratios come across as the most popular and most reported in the literature: Insall and Salvati [6] in 1971, Blackburne and Peel [7] (BP) in 1977, Caton-Deschamps [1] in 1982, and modified Insall and Salvita (mIS) by Grelsamer [8] in 1992. The CD index could not be used exactly after TKA. So, since 2008 [9], and specifically for TKA, we have used our modified CD index, termed the modified Caton index

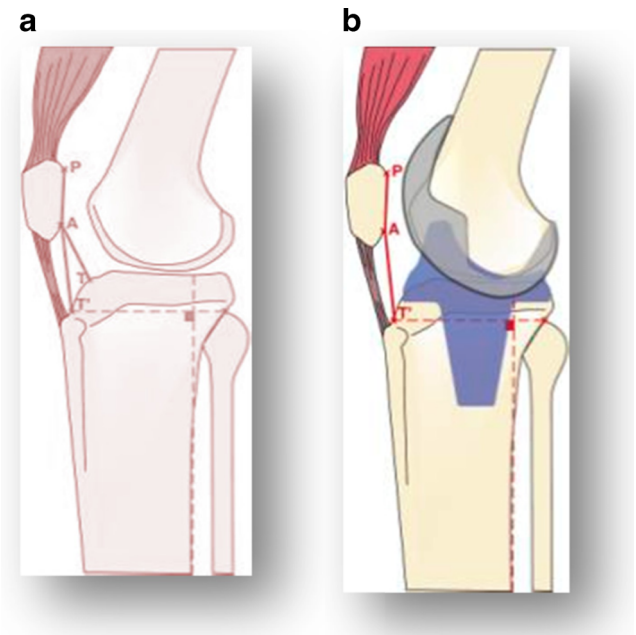

Fig. 2 Modified pre-operative (**a**) and post-operative (**b**) Caton-Deschamps index (mCD)

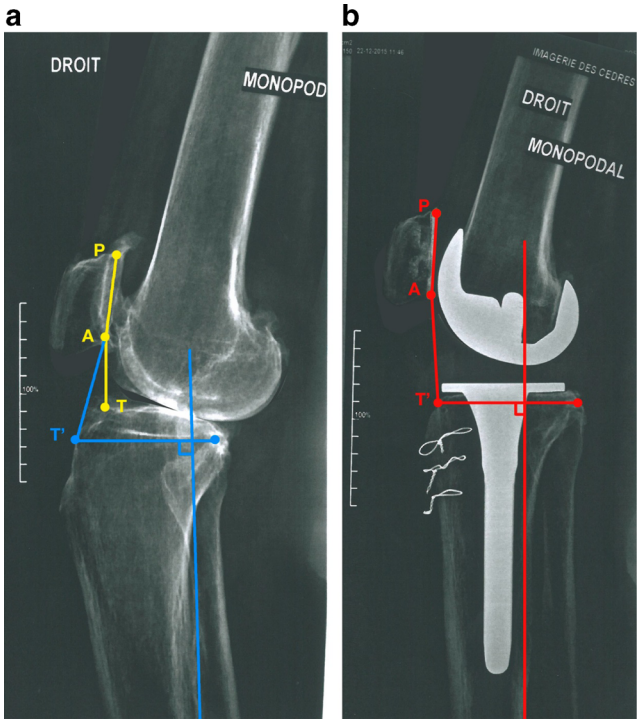

Fig. 3 Pre-operative Caton-Deschamps index (CD) and modified CD (mCD) index (**a**) and post-operative mCD index (**b**) Postero-stabilized New Wave (groupe lépine)

(mCD), to conduct a real assessment of patellar height after TKA (Fig. 2b).

The main objective of this study was to describe and validate this new method of patellar height measurement in relation to knee arthroplasty.

Table 1 Mean (standard deviation) patellar height index

	CD	Pre-operative mCD	Post-operative mCD
JC			
Measurement 1	0.99 ± 0.16	1.39 ± 0.21	1.24 ± 0.15
Measurement 2	0.95 ± 0.24	1.36 ± 0.25	1.17 ± 0.18
JLP			
Measurement 1	0.94 ± 013	1.29 ± 0.15	1.12 ± 0.15
Measurement 2	0.96 ± 0.11	1.29 ± 0.15	1.09 ± 0.15
RV			
Measurement 1	0.89 ± 0.16	1.34 ± 0.20	1.11 ± 0.17
Measurement 2	0.90 ± 0.25	1.34 ± 0.34	1.12 ± 0.17

JC, JLP, RV observers, *CD* Caton-Deschamps index, *mCD* modified Canton-Deschamps index

Materials and methods

Description of the measurement method

Since 1982 we have used our original method [1, 10–13] to evaluate patellar height in normal and symptomatic knees using sagittal X-ray view. The latter (CD) is calculated by dividing the distance from the distal portion of the articular surface of the patella to the anterosuperior angle of the tibial plateau (AT) by the length of the articular surface of the patella (AP) on lateral radiograph of the knee flexed to at least 10° (Fig. 1). This AT/AP ratio varies between 0.96 ± 0.134 for men and 0.99 ± 0.129 for women, i.e. hardly different from 1 [1]. The normal range of patellar height with this CD ratio is between 0.6 (patella infera) and 1.2 (patella alta) [10–13]. Measurement of patellar height with the use of the CD ratio is possible regardless of X-ray quality, knee size, patient age, degrees of enlargement, range of motion (ROM) between 10° and 80°, position of the tibial tubercle or patellar modifications related to fractures or ossifications of the inferior pole. The three major characteristics of our method are: first, AP measurement, which eliminates patellar abnormalities; second, the T mark (AT), which eliminates tibial or tibial tubercle modifications; third, AT/AP ratio, which eliminates ROM problems (flexion degrees). After TKA, the T landmark of the CD index is no longer available, so a new T' landmark must be defined. This point is situated at the intersection between the line perpendicular to the tibial posterior cortex elevated at the tip of the fibular head and the tibial anterior cortex. This remarkable new landmark can be identified before and after TKA, with a new relative index AT'/AP ratio (Fig. 2a). This modified method allows comparison of patella height before and after TKA [9].

Validation of the measurement method

Among a consecutive series of 60 knees operated on for TKA between April 2014 and April 2015 by one senior surgeon, we selected a study population comprising the first 30 knees to confirm the results of this assessment described for the first time in 2008 [9]. The patella has been replaced in all cases by a full polyethylene cemented component. Radiological exam included pre- and post-operative frontal and lateral X-rays in full weight bearing. Three different observers (the authors) were involved in performing the measurements (Fig. 3): JC and JLP as orthopaedic surgeons, and RV as epidemiologist. JC carried out measurement manually; JLP and RV used standard software (PowerPoint® 2011, Microsoft Office). On each knee, each observer performed twice, with a minimum interval of 3 weeks, five measurements (pre-operative: AP, AT and AT', post-operative: AP and AT') to calculate three index (pre-operative CD and mCD as well as post-operative mCD). Overall, 900 values were measured.

Table 2 Repeatability: intraobserver intra-class correlation coefficient of patellar height index

	CD	Pre-operative mCD	Post-operative mCD
JC			
ICC	0.59	0.57	0.63
95 % CI	0.30-0.78	0.27-0.77	0.32-0.81
JLP			
ICC	0.67	0.60	0.75
95 % CI	0.41-0.82	0.31-0.79	0.54-0.87
RV			
ICC	0.69	0.58	0.68
95 % CI	0.44-0.84	0.28-0.78	0.43-0.84

JC, JLP, RV observers, *ICC* intra-class correlation coefficient, *CI* confidence interval, *CD* Caton-Deschamps index, *mCD* modified Canton-Deschamps index

Table 3 Reproducibility: inter-observer intra-class correlation coefficient of patellar height index

	CD	Pre-operative mCD	Post-operative mCD
ICC	0.64	0.72	0.68
95 % CI	0.42–0.80	0.56–0.84	0.43–0.83

ICC intra-class correlation coefficient, *CI* confidence interval, *CD* Caton-Deschamps index, *mCD* modified Canton-Deschamps index

Statistical analysis

Data were collected on Excel® (Microsoft, Redmond, WA, USA). As there are no reference values (the goal of this method is to compare pre- and post-operative values), we only assessed repeatability (on two measurements) according to Langlois and Hamadouche [14] (usually called intra-observer reliability [15–17]) and reproducibility (three observers), always according to Langlois and Hamadouche [14] (usually called inter-observer reliability [15–17]), of CD and mCD owing to an ICC with its 95 % confidence interval (CI) [15–17] calculated with Real Statistics for Excel®.

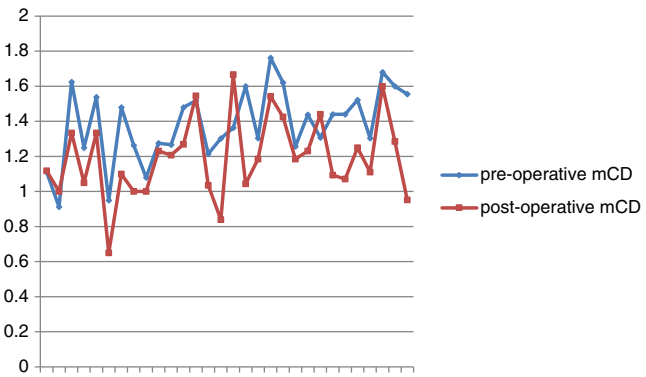

Fig. 4 Pre-operative and post-operative modified Caton-Deschamps (mCD) index

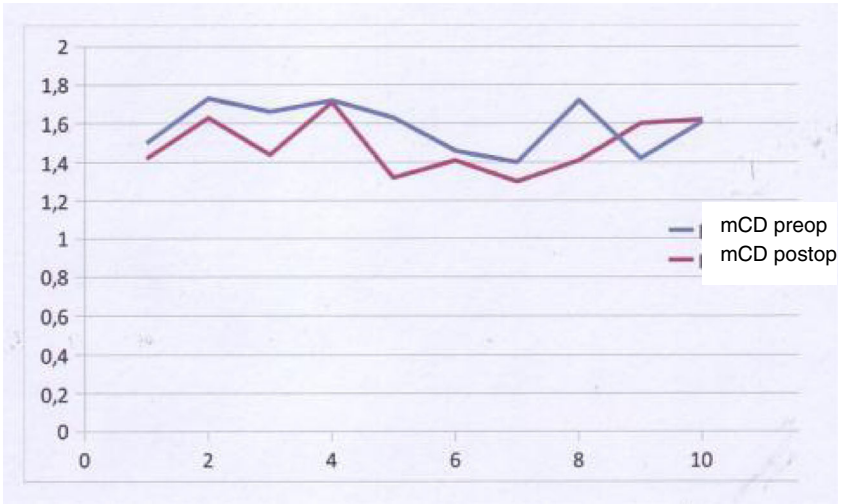

Fig. 5 Pre-operative and post-operative modified Canton-Deschamps (mCD) index: postero-stabilized total knee arthroplasty (TKA), with permission from [9]

Results

Mean age of patients in this series was 70.8 (53–90) years with three previous surgeries (high tibial osteotomies); 43 % were women. There was no pre-operative patella infera (CD ≤0.6) but two patella alta (CD ≥1.2). Intra- and inter-observer ICC are presented in Tables 1,2 and 3. Intra-observer reliability was good, with ICCs between 0.58 and 0.75 among the three observers and the three indexes (CD and pre- and post-operative mCD). Inter-observer reliability was considered good, with ICC ranging from 0.64 to 0.72.

Mean (standard deviation) patellar height index is reported in Table 1. In all patients, after TKA patella position is—in the majority of cases—in a lower position (mean difference between pre- and post-operative mCD 0.19) (Fig. 4).

Discussion

ICCs of mCD are good and are comparable with those previously published for CD, BP and mIS index. Even though Rogers et al. [16] reported that both BP and CD have superior reliability and a good inter-observer correlation after TKA, it is our opinion that our original method (CD) is not really suitable for use after TKA. For Phillips et al. [17], just as for Blackburne and Peel, our method (CD) seems to have better accuracy and reproducibility in normal and symptomatic knees. For Thevenin-Lemoine et al. [18], CD is the best method to investigate patellar height in children. Aparicio et al. [19] also found this CD ratio was more reliable and reproducible than the BP. In only one recent publication [20] was inter-observer reliability reported as being poor for CD (but the cutoff point used to define patella alta was 1.3 and not ≥1.2) [10–13], whereas intra-observer reliability was very strong. For TKA patella height, measurement must be assessed with the original (CD) method (AT/AP) to detect a true patella infera before TKA, which could influence the surgical approach to avoid difficulties with extensor apparatus. Before TKA, CD and mCD must be assessed. Modification of patella height after TKA could be evaluated through the modified index and had to be compared with changes in position of the joint line. In our series, after TKA, patella position is lowered, as reported in 2008 [9] (Fig. 5). Is it a true patella infera or a pseudo patella infera?

Grelsamer, in 2002, defined a new theory about patellar height in TKA: the pseudo patella baja [21]. In our opinion, the Spanish term baja is not consistent with the Latin term patella; since 1982, we have used the Latin term infera [1]. According to Grelsamer, if the joint line is raised sufficiently, the ratio is low, suggesting a pseudo patella infera [21]. True patella infera is detected most reliably by the original CD (AT/AP) index before TKA, whereas a pseudo patella infera can be detected only by the mCD index pre- and post-TKA. These results could be also compared with functional results of the TKA, with potential limitation of motion and potential pain in case of true post-operative patella infera with extensor mechanism lesions [22]. In case of pseudo patella infera with a normal patellar tendon length, the problem is probably secondary to the femoral and tibial cuts [23]. Is it a mild raising of the joint line or a major raising with a significant mechanical problem with the knee? Our results confirm that this new index is reliable for assessing patellar height before and after TKA. This new index can be used to assess the impact on clinical outcomes of patellar height changes. Further studies are required to analyse why TKA may modify patellar height.

Compliance with Ethical Standards

Conflict of interest Jacques H Caton and Jean-Louis Prudhon are consultant for groupe lépine.

Thierry Aslanian and Régis Verdier are employed by groupe lépine.

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