Knee Surgery, Sports Traumatology, Arthroscopy (2018) 26:1831–1837
https://doi.org/10.1007/s00167-017-4828-8

KNEE

Pseudo-patella baja: a minor yet frequent complication of total knee arthroplasty

Giulia Bugelli[1] · Francesco Ascione[2] · Niki Cazzella[3] · Edoardo Franceschetti[4] · Francesco Franceschi[4] · Giacomo Dell'Osso[5] · Eleonor Svantesson[6] · Kristian Samuelsson[6,7] · Stefano Giannotti[8]

Received: 4 August 2017 / Accepted: 18 December 2017 / Published online: 23 December 2017

Abstract

Purpose One of the complications in total knee arthroplasty (TKA) is pseudo-patella baja (PPB). PPB is present when there is no shortening of the patellar tendon, but the joint line is elevated. The purpose of this study is to investigate the incidence of PPB after TKA and its clinical effects.

Methods A case series of 158 patients undergoing TKA surgery between 1999 and 2012 at the 2nd Department of Orthopaedics and Traumatology, Pisa were retrospectively reviewed. Surgeries were performed by three senior surgeons, using the same surgical procedure for the implantation of a cemented posterior stabilized prosthesis. Lateral radiographs at 30° knee flexion were evaluated and the presence of PPB defined as modified Blackburne–Peel Index (mBPI) of <0.54. All the patients were clinically evaluated using the Knee Society Score (KSS) and the Western Ontario and McMaster Universities Osteoarthritis Index score (WOMAC). Anterior knee pain was evaluated by visual analogue scale (VAS) and range of motion (ROM) was assessed through clinical examination.

Results The cohort group consisted of 158 patients, 109 (69.0%) female and 49 (31.0%) male. Median age at time of surgery was 74 years (range 36–87) and median follow-up was 66 months (range 12–163 months). Bilateral TKA surgery was performed in 50 patients, resulting in a total of 208 implants for investigation. On radiological evaluation, 139 (66.8%) showed no abnormalities (no joint line elevation and no patellar tendon shortening) and 55 (26.4%) presented joint line elevation with absence of patellar tendon shortening (PPB). No significant differences were found between the groups in terms of the KSS, WOMAC score, VAS or ROM.

Conclusion Post TKA PPB is a relatively common complication. Careful preoperative planning, adequate soft tissue release, optimal cutting of bone components, on the femoral side in particular, and the use of thin polyethylene inserts can help to avoid this complication.

Level of evidence IV.

Keywords Pseudo-Patella Baja · Patella Baja · Total Knee Arthroplasty · Modified Blackburne-Peel · Insall-Salvati · Clinical outcomes · Complications · Anterior pain

✉ Giulia Bugelli
bugeposta@hotmail.it

[1] Humanitas Clinical and Research Center, Via Manzoni 56, 20089 Rozzano, Milan, Italy

[2] Shoulder Surgery Division, Campolongo Hospital, Salerno, Italy

[3] Orthopedics and Traumatology Department, Ospedale Vito Fazzi, Lecce, Italy

[4] Department of Orthopaedic and Trauma Surgery, Campus Bio-Medico University, Rome, Italy

[5] Orthopedics and Traumatology Department, Ospedale San Luca, Lucca, Italy

[6] Department of Orthopaedics, Institute of Clinical Sciences, The Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden

[7] Department of Orthopaedics, Sahlgrenska University Hospital, Mölndal, Sweden

[8] Orthopedics and Traumatology Department, University of Siena, Siena, Italy

Introduction

Total knee arthroplasty (TKA) is a common procedure for patients with chronic knee pain and osteoarthritis. According to the Agency for Healthcare Research and Quality, more than 750,000 TKA procedures were performed during 2014 in the United States [13]. The most frequent post-operative complications of TKA involve the patello-femoral joint: stiffness, instability, patellar fracture and tendon injury. Moreover, abnormal knee kinematics and ligament strain are likely to be the consequences when the surgery alters the native position of the tibiofemoral joint. This condition can, in fact, negatively affect the procedure's outcome [16].

Two different conditions resulting from mal-positioned patella in relation to the tibiofemoral joint line have been reported: Patella baja (PB) and pseudo-patella baja (PPB). PB is a congenital condition characterized by patellar tendon shortening as a result of the excessively distal position of the patella in relation to the femoral trochlea, whereas PPB is an iatrogenic condition occurring when the femoraltibial joint line is elevated as a result of excessive cutting of the femur, marked tissue loss, or decreased tibial cut [25]. In fact, the patella remains in a normal position in relation to the femoral trochlea and the patellar tendon retains its original length [16] (Fig. 1). The presence of PPB following TKA has been reported in 34–65% of cases [16].

A tibial polyethylene insert of greater thickness than normal might be utilized to compensate for the altered anatomy and subsequent instability of the system, thus countering the iatrogenic alteration that PPB produces [3, 24]. The main post-operative concerns of this technique include: decreased range of motion, decreased lever arm, anterior knee pain, anterior impingement between the patella and the tibial insert, and patellar tendon rupture [19].

Few studies have investigated the consequences of PPB following TKA [8, 9, 11, 12, 16, 25, 28, 29]. Consequentially, exactly how PPB affects outcome and function in patients undergoing TKA, or how frequently this undesirable condition occurs is not yet fully understood.

PPB may play a role in anterior knee pain after TKA, post-operatively affecting the range of motion, and recognizing PPB might guide a surgeon in explaining unsatisfactory results and in indicating reoperations [26].

The purpose of this study is to investigate the occurrence of PPB and its clinical consequences in a large series of patients undergoing TKA at long-term follow-up.

Materials and methods

A case series of 158 patients who underwent TKA surgery between May 1999 and November 2012 at the 2nd Department of Orthopaedics and Traumatology of Pisa were retrospectively reviewed. The cohort consisted of 158 patients, 109 (69.0%) female and 49 (31.0%) male. Median age at time of surgery was 74 years (range 36–87) and median follow-up was 66 months (range 12–163 months). Bilateral TKA surgery was performed in 50 patients, resulting in a total of 208 implants for investigation. All the patients were considered eligible for participation with the exception of those whose plain radiographs revealed existing PB. Medical records for all the cases were reviewed and data on age,

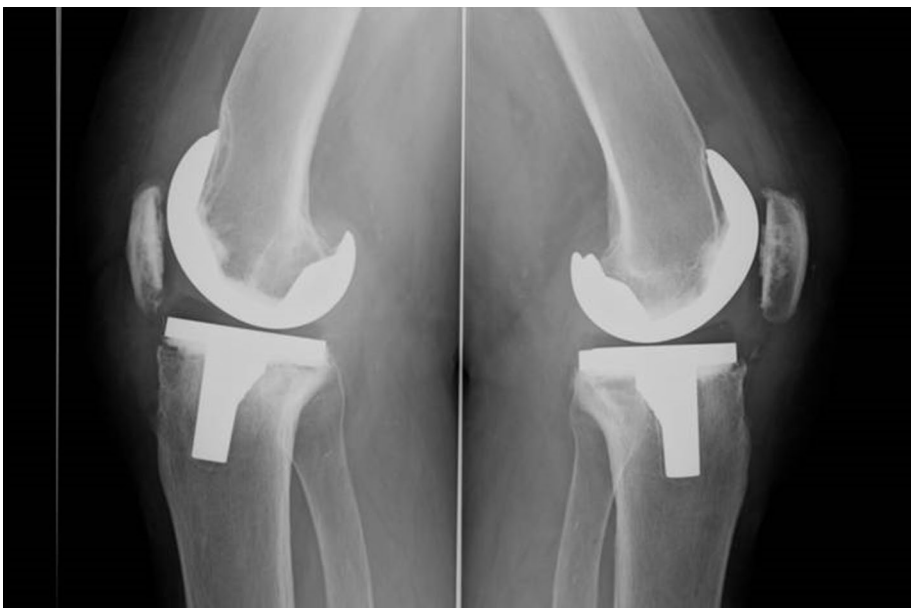

Fig. 1 Difference between real patella baja (left) and pseudo-patella baja (right)

gender and date of surgery were extracted. Each patient was asked for study participation via a phone call and, once informed consent had been obtained, the patient was scheduled for clinical examination. No pre-specified minimum or maximum follow-up was determined. Thus, all the patients were asked to participate in the study, regardless of the time lapse since the surgery.

Surgical procedure

Three senior surgeons performed all the surgeries using the same surgical procedure for implantation of a cemented posterior stabilized prosthesis. The implanted prosthesis were Scorpio (Stryker Orthopaedics, Mahwah, NJ, USA) or Vanguard® Posterior Stabilized Knee (Biomet, Warsaw, Indiana, USA). A non-sterile pneumatic tourniquet was placed as proximally as possible on the thigh to maximize the area for surgical exposure, when necessary, and it was set between 250 and 350 mmHg. A cutaneous midline incision was made, running from a point 2 cm proximal to the upper pole of the patella to the anterior tibial tuberosity, following the midline of the knee, with the knee in a flexed position. The length of the incision was determined by the size of the knee and the patient's body mass index (BMI). A slightly curvilinear and laterally concave medial parapatellar capsular incision was made, by incising proximally from a point 2 cm proximal to the upper pole of the patella, and continuing distally to the anterior tibial tuberosity whilst maintaining a 3 mm medial cuff of tendon. Lateral eversion of the patella was performed with the knee extended. Subsequently, the knee was flexed to expose the knee joint while keeping the patella laterally everted. The Hoffa fat pad, the menisci, and the anterior and posterior cruciate ligaments were excised. Loose bodies and osteophytes on the tibia and the femur were carefully removed. The medial and lateral collateral ligaments were protected during bone cutting [21]. Bone cuts and implantation were performed following the selected knee prosthesis technique. The tourniquet was deflated after prosthesis implantation to allow for adequate haemostasis.

Radiographic evaluation

Radiographs were taken to assess patellar height. To minimize inter-observer variation, all the measurements were taken independently by two residents. Each patient's imaging was accessed using the picture archiving and communication system Synapse PACS (Fujifilm Medical Systems, Stemford, CT, U.S.A.). Lateral weight bearing radiographs, at 30° knee flexion with overlaying femoral condyles, were evaluated. None of the radiographs analysed deviated from the set acceptable position, which had been established as < 5 mm between the femoral contours. The joint line was defined as the distal aspect line of the femoral condyles. The modified Blackburne–Peel Index (mBPI) [1, 4, 6, 20] was used to evaluate the relationship between patellar height and the joint line. mBPI was preferred since it does not require visualization of the anterior superior margin of the polyethylene insert. This can prove difficult to identify on radiographic images, thus affecting the reproducibility of measurements (Fig. 2a). Furthermore, because neither the polyethylene insert nor the tibial plateau is a factor in mBPI, results are not affected by tibial slope. The mBPI is obtained by assessing the distance

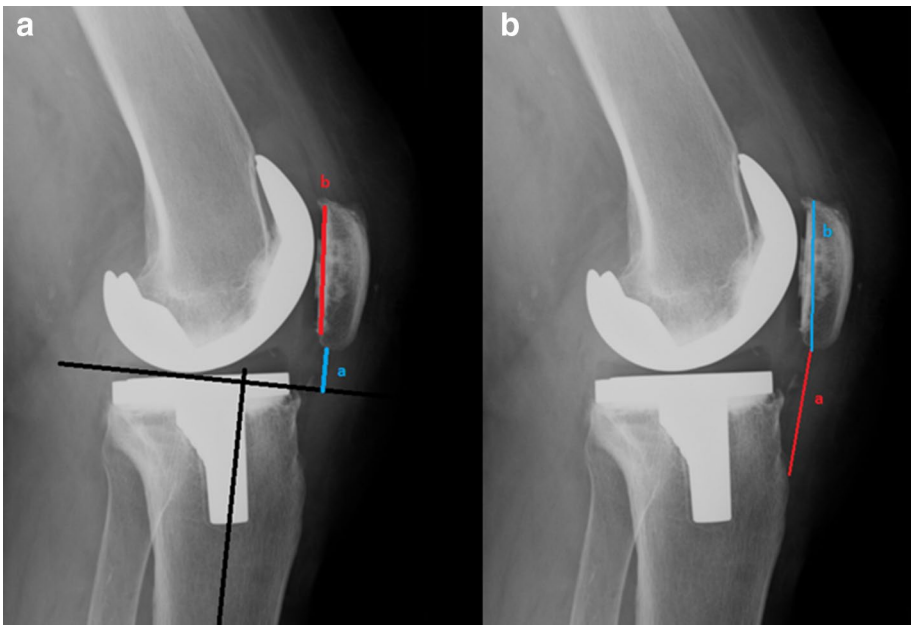

Fig. 2 **a** The modified Blackburne-Peel Index is calculated as **a/b. b** The Insall-Salvati ratio is calculated as **a/b**

between the lowest point of the patella and the lowest point of the femoral condyles tangent, perpendicular to the tibial shaft. This is subsequently divided by the length of the articular surface of patella in the lateral X-ray view. The presence of PPB was defined as an mBPI of < 0.54.

The Insall-Salvati Ratio (ISR) [14], the ratio between the length of the patellar tendon and the longitudinal diameter of the patella, was used to identify shortening of the patellar tendon, i.e., PB. ISR < 0.8, signified the presence of PB and the patient was excluded from further analysis [14, 15] (Fig. 2b).

All the imaging measurements were taken with Synapse PACS by Fujifilm, providing measurements of linear values of up to 0.01 mm and angular values of up to 0.01°.

Outcome

Clinical evaluation was carried out using the Knee Society Score (KSS) and Western Ontario and McMaster Universities Osteoarthritis Index score (WOMAC) [15]. Anterior knee pain was assessed through the visual analogue scale (VAS). A score of 0 was classified as "no pain", 1–4 "mild pain", 5–7 "moderate pain" and 8–10 "severe pain". Knee flexion was evaluated using section "total range of flexion" in KSS.

Ethics

Because the study involved only routine clinical follow-up and radiographic examination, under Italian law, ethical approval was not required. Written informed consent was obtained from all the patients involved, where the patients consented to surgical treatment and the collection and publication of their clinical data for scientific and educational purposes within the 2nd Department of Orthopaedics and Traumatology, Pisa and outside. All the details that might disclose the subjects' identity were omitted.

Statistical analysis

Statistical analysis was performed with http://www.socscistatistics.com. Paired Student t tests were utilized to compare variables between the study groups. A p value of < 0.05 was considered significant. The sample size used in this study (55 knees with PPB and 139 without PPB) gives a power of 87.7%, distinguishing 1.5 points of difference in pain (measured on VAS scale), considering common standard deviation 3 and alpha error.

Results

The radiological evaluation of the 208 knees after TKA surgery revealed that 139 (66.8%) showed no abnormalities (no joint line elevation and no patellar tendon shortening), 55 (26.4%) revealed joint line elevation in absence of patellar tendon shortening (PPB) and 14 (6.7%) revealed patellar tendon shortening with or without simultaneous elevation of the joint line (Solely PB or combined PB + PPB) (Table 1). The median time to follow-up was 66 months (range 12–163 months).

Only patients presenting with normal patellar position (Group A) and PPB (group B) were subjected to clinical evaluation and further analysis. A total of 50 patients (12 males and 38 females) presented with PPB, of which 5 patients had undergone bilateral TKA where PPB was evident in both the procedures. Thus, the total number of TKA procedures in this group was 55. Median age at the time of surgery for the PPB group was 72 years (53–85) and median follow-up was 65 months (range 12–147 months). The thickness of the polyethylene inserts in these TKA procedures was as follows: 8 mm in 4 knees (7.3%), 10 mm in 31 knees (56.4%), 12 mm in 18 knees (32.7%) and 14 mm in 2 knees (3.6%). No significant differences were found between clinical and functional scores in patients in group A and patients in group B, and the proportion of patients with knee flexion in excess of 110° was similar (Table 2).

Ninety-five knees (62.0%) in group A and 30 knees (54.5%) in group B reported no pain at follow-up The proportion of patients reporting mild and moderate pain was higher in group B and severe pain was reported by 3 knees (1.9%) in group A compared with 3 knees (5.5%) in group B. However, no significant differences in terms of pain were found (Table 3).

Discussion

The most important finding of the present study was the frequency of PPB, observed in 26.4% of the 208 consecutive TKA implants. Nevertheless, the presence of this or post-operative complication of the surgical procedure was

Table 1 Study groups following radiological evaluation

		n	%	ISR	mBPI
Group A	Normal patellar position	139	66.8	> 0.8	> 0.54
Group B	PPB	55	26.4	> 0.8	< 0.54
Group C	PB or PB + PPB	14	6.7	< 0.8	Any value

PPB pseudo-patella baja, *PB* patella baja, *ISR* insall-salvati ratio, *mBPI* modified Blackburne–Peel Index

Table 2 Comparison of clinical outcomes between groups

	KSS mean (min–max)	Functional KSS mean (min–max)	WOMAC mean (min–max)	Flexion > 110° mean (%)
Group A	86.7 (33–100)	87.8 (35–100)	84.1 (55–100)	65.4
Group B	84.2 (31–100)	85.1 (30–100)	82.9 (52–100)	66.3
p value	n.s	n.s	n.s	n.s

KSS Knee Society Score, *WOMAC* Western Ontario and McMaster Universities Osteoarthritis Index score

Table 3 Comparison of anterior knee pain between groups

	No pain *N* (%)	Mild pain *N* (%)	Moderate pain *N* (%)	Severe pain *N* (%)
Group A	95 (62.0%)	43 (28.2%)	12 (7.9%)	3 (1.9%)
Group B	30 (54.5%)	16 (29.0%)	6 (11.0%)	3 (5.5%)
p value	n.s	n.s	n.s	n.s

The visual analogue scale was applied and level of pain defined as; A score of 0 = no pain, 1–4 = mild pain, 5–7 = moderate pain, 8–10 = severe pain

not associated with increased anterior knee pain or inferior patient-reported outcome when compared with patients without post-operative PPB. Unlike the results of previous studies, PPB was not associated with limited active or passive articular ROM [16].

It has been reported in literature that 5–10% of patients experience anterior knee pain after total knee arthroplasty [2]. Joint line elevation after TKA can lead to decreased ROM, and restoration of the proper joint line is a major factor towards successful outcome after TKA. Thornton-Bott et al. [25] demonstrated that TKA surgery created a PPB in 26.7% of cases. The incidence of PPB reportedly increased in proportion to the extent of soft tissue release and the use of polyethylene inserts of increased thickness. No association between the presence of PPB and clinical outcome was found, which is consistent with the current studies. In another study, Schwab et al. [22] concluded that PPB is a relatively common complication negatively affecting knee function after endoprosthetic reconstruction. The study further emphasized that the position of the joint line warrants particular attention in distal femoral replacement. Conversely to the results presented in this study, Kazemi et al. [16] showed a significant association between PPB and PPB/PB and increased pain and decreased ROM. However, no difference was found in terms of KSS when these groups were compared to patients without joint line elevation or patellar tendon shortening [16]. Similarly, Chonko et al. [5] reported that patella baja caused by joint line elevation after TKA is likely to result in anterior knee pain, decreased ROM, and patella component impingement on the tibia or the polyethylene insert.

Conversely, Van Houten et al. [27] concluded that anterior knee pain and lower clinical scores are not explained by a radiographic abnormal position, patellar height or the amount of patellar displacement/tilt, regardless the type of bearing.

It appears that recreating the natural position of the joint line is fundamental to optimal patello-femoral biomechanics. The patella plays a crucial role in the biomechanics of the knee, extending the lever arm of the extension mechanism, thus improving the demonstrable strength of the quadriceps by 30–50%. The height of patella alters joint reaction force at any point in the flexion–extension cycle of the knee [20]. Altered patellar height, as occurs in PPB, is a result of the joint line being set higher than normal during surgery. Several detrimental effects have been reported following changes in the joint line, such as inferior knee function, wear of the polyethylene implant and distal patella movement when compared to the preoperative position [7, 10, 18]. Martin et al. [17] explained that when the original joint line is well-preserved post-operatively, stability is also preserved. Thus, intra-operative awareness of patellar tracking, including knowledge of the joint line level, is of paramount importance, if PPB is to be avoided. Recently, Seo et al. [23] reported that when adding a metal block at the distal femoral block during surgery, distal femoral bone resection can be minimized and consequently, joint line is maintained and PPB avoided [23]. To reduce the risk for PPB, the following factors should be observed when performing TKA: timely surgery, careful preoperative radiographic evaluation, meticulous patellar tracking, positioning the reconstructed joint line as closely as possible to the natural joint line, and consistent immediate and prolonged rehabilitation with appropriate analgesia [27].

The presence of PPB in this study population was determined by radiologic evaluation implementing validated scores. Accuracy of measurement may be influenced by the fact that determination of the exact reference point on the

anterior tibial tuberosity in patellar tendon measurement and the length of patellar articular surface is challenging. Although the Institution has described the procedure for taking lateral radiographs of the knee in detail, an unspecified (assumed to be small) error margin remains, which may impact upon the reproducibility of measurements. None of the radiographs analysed in this study demonstrated high deviation from an acceptable position (< 5 mm between the two femoral contours). Furthermore, radiograph images are taken in a supposedly 30° flexion position of the knee, but there could be difficulties in real reproduction of this position, and it could reflect on difference of measurements. This study is further limited by the absence of information regarding any concomitant pathology of the knee joint, or the presence of any other physical condition in the study population, which may affect the outcome scores. Moreover, the proportion of patients with and without patellar resurfacing in addition to PPB was not investigated. Thus, no conclusions can be drawn regarding the influence of patellar resurfacing. It should be emphasized that this study was limited to the analysis of the influence of PPB, but did not investigate any possible effects that prosthesis type or positioning may have. The lack of evaluation of axial radiographic images and patello-femoral joint mechanics, important factors in good outcome and survival of the implant, are a further limitation of this study. Investigation of the role played by patellar resurfacing and patella-femoral mechanics in association with PPB should be addressed in future studies.

Furthermore, the length of follow-up for patients examined varied: no correlation between follow-up, presence of PPB and clinical outcomes has been drawn.

PPB is associated with a statistically non-significant decrease in ROM, clinical outcomes (KSS and WOMAC scores) and anterior knee pain, but it can cause anterior impingement, wear of the polyethylene tibial insert and changes in patello-femoral mechanics, complications which were not investigated in this study and which have not yet been discussed in literature. Avoiding PPB after TKA in daily clinical practice would be an important step towards preventing these complications.

Conclusion

Although post TKA PPB is a relatively common complication, in this study, differences in terms of clinical outcome, when comparing patients with PPB and patients without, were non-significant. Careful preoperative planning, adequate soft tissue release, optimal cutting of bone components, especially on the femoral side, and the use of thin polyethylene inserts can assist in positioning the reconstructed joint line as close as possible to its natural position, thus avoiding the complications which have been observed to date, such as loss of ROM, anterior knee pain, anterior impingement, tibial insert wear, or changes in patello-femoral mechanics.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Funding There has been no financial supports or industry affiliations of all those involved in this project.

Ethical approval According to Italian laws, ethical approval for this study was not required, because it involved only routine clinical follow-up and radiographic examination.

Informed consent Written informed consent has been obtained from all the patients participating in the study.

References

1. Blackburne JS, Peel TE (1977) A new method of measuring patellar height. J Bone Jt Surg Br 59(2):241–242
2. Breugem SJ, Haverkamp D (2014) Anterior knee pain after a total knee arthroplasty: what can cause this pain? World J Orthop 5(3):163–170
3. Cameron HU, Jung YB (1988) Patella baja complicating total knee arthroplasty. A report of two cases. J Arthroplasty 3(2):177–180
4. Caton J, Deschamps G, Chambat P, Lerat JL, Dejour H (1982) [Patella infera. Apropos of 128 cases]. Rev Chir Orthop Reparatrice Appar Mot 68(5):317–325
5. Chonko DJ, Lombardi AV Jr, Berend KR (2004) Patella baja and total knee arthroplasty (TKA): etiology, diagnosis, and management. Surg Technol Int 12:231–238
6. Classen T, Wegner A, von Knoch M (2009) [Modification of the Blackburne-Peel ratio for improved application in total knee arthroplasty]. Orthopade 38(12):1229–1234
7. Estupinan JA, Bartel DL, Wright TM (1998) Residual stresses in ultra-high molecular weight polyethylene loaded cyclically by a rigid moving indenter in nonconforming geometries. J Orthop Res 16(1):80–88
8. Floren M, Davis J, Peterson MG, Laskin RS (2007) A mini-midvastus capsular approach with patellar displacement decreases the prevalence of patella baja. J Arthroplasty 22(6 Suppl 2):51–57
9. Gatha NM, Clarke HD, Fuchs R, Scuderi GR, Insall JN (2004) Factors affecting postoperative range of motion after total knee arthroplasty. J Knee Surg 17(4):196–202
10. Goldberg VM, Figgie HE 3rd, Figgie MP (1989) Technical considerations in total knee surgery. Management of patella problems. Orthop Clin North Am 20(2):189–199
11. Grelsamer RP (2002) Patella baja after total knee arthroplasty: is it really patella baja? J Arthroplasty 17(1):66–69
12. Grelsamer RP, Meadows S (1992) The modified Insall-Salvati ratio for assessment of patellar height. Clin Orthop Relat Res (282):170–176
13. Healthcare Cost and Utilization Project (HCUP) (2017) Nationwide inpatient sample. Agency for Healthcare Research and Quality. https://www.hcup-us.ahrq.gov/faststats/NationalProceduresServlet
14. Insall J, Salvati E (1971) Patella position in the normal knee joint. Radiology 101(1):101–104

15. Insall JN, Dorr LD, Scott RD, Scott WN (1989) Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res (248):13–14
16. Kazemi SM, Daftari Besheli L, Eajazi A, Miniator Sajadi MR, Okhovatpoor MA, Farhang Zanganeh R, Minaei R (2011) Pseudo-patella baja after total knee arthroplasty. Med Sci Monit 17(5):Cr292–C296
17. Martin JW, Whiteside LA (1990) The influence of joint line position on knee stability after condylar knee arthroplasty. Clin Orthop Relat Res (259):146–156
18. Rand JA (1990) Patellar resurfacing in total knee arthroplasty. Clin Orthop Relat Res (260):110–117
19. Robin BN, Ellington MD, Jupiter DC, Allen BC (2014) Plateau-patella angle in evaluation of patellar height after total knee arthroplasty. J Arthroplasty 29(7):1394–1397
20. Rogers BA, Thornton-Bott P, Cannon SR, Briggs TW (2006) Interobserver variation in the measurement of patellar height after total knee arthroplasty. J Bone Jt Surg Br 88(4):484–488
21. Sanna M, Sanna C, Caputo F, Piu G, Salvi M (2013) Surgical approaches in total knee arthroplasty. Joints 1(2):34–44
22. Schwab JH, Agarwal P, Boland PJ, Kennedy JG, Healey JH (2006) Patellar complications following distal femoral replacement after bone tumor resection. J Bone Jt Surg Am 88(10):2225–2230
23. Seo JG, Moon YW, Kim SM, Park SH, Lee BH, Chang MJ, Jo BC (2015) Prevention of pseudo-patella baja during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 23(12):3601–3606
24. Sharma V, Tsailas PG, Maheshwari AV, Ranawat AS, Ranawat CS (2008) Does patellar eversion in total knee arthroplasty cause patella baja? Clin Orthop Relat Res 466(11):2763–2768
25. Thornton-Bott P, Unitt L, Johnstone DJ, Sambatakakis A, the Balancer Study Group (2012) Pseudo-patella baja following soft tissue balancing in total knee arthroplasty. Orthop Proc 94-b(supp II):119
26. Vandeputte FJ, Vandenneucker HBone Joint J (2017) Proximalisation of the tibial tubercle gives a good outcome in patients undergoing revision total knee arthroplasty who have pseudo patella baja. Bone Jt J 99-B(7):912–916
27. Van Houten AH, Heesterbeek PJ, Wymenga AB (2016) Patella position is not a determinant for anterior knee pain 10 years after balanced gap total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 24(8):2656–2662
28. Weale AE, Murray DW, Newman JH, Ackroyd CE (1999) The length of the patellar tendon after unicompartmental and total knee replacement. J Bone Jt Surg Br 81(5):790–795
29. Yoshii I, Whiteside LA, White SE, Milliano MT (1991) Influence of prosthetic joint line position on knee kinematics and patellar position. J Arthroplasty 6(2):169–177