

Original Article

Patella baja after revision total knee arthroplasty

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A B S T R A C T

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Background: Patella baja happens after revision total knee arthroplasty (TKA), by patellar ligament shortening and/or elevated joint line ("pseudo" patella baja), and may restrict knee flexion.

Methods: We studied 29 revision TKA of the same surgical procedure and type of prosthesis with an average follow-up of 28.3 months.

Results: At the last follow-up, patella baja was found in 59%, 83%, and 90% of patients, as defined by Insall-Salvati (IS), Blackburne-Peel, and Caton-Deschamps indexes, respectively. Higher incidence by the latter two indexes indicated existence of pseudo patella baja. Mean maximal flexion angle was 95.5°, poorly correlated with any of the three indexes by linear regression. Mean maximal flexion angle of IS index-defined patella baja knees (97.9°) was not significantly different from that of the nonbaja knees (92.1°). Mean IS index significantly decreased after surgery (0.82–0.78), but joint line position did not change significantly.

Conclusion: Both true and pseudo patella baja could exist after revision TKA but would not restrict knee flexion.

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1. Introduction

Patella baja, the condition of lower position of patella relative to the distal femur, may occur after various knee surgeries such as reconstruction of the anterior cruciate ligament, high tibial osteotomy, and total knee arthroplasty (TKA).^{1,2} Patella baja usually develops by the shortening of the patellar tendon that pulls the patella toward the tibial tuberosity, but may also occur after prosthetic arthroplasty with the proximal shift of joint line, known as the "pseudo" patella baja.³

Several methods were advocated to quantify patella baja (Fig. 1). The Insall-Salvati (IS) index is the ratio of the patellar tendon length to the diagonal length of the patella.⁴ The Blackburne-Peel (BP) index is the ratio of the articular

surface length of the patella to the height of the lower pole of the articular surface above the tibial plateau.⁵ The Caton-Deschamps (CD) index is the ratio of the distance between the distal pole of the patellar articular surface and the anterosuperior border of the tibia against the length of the articular surface of the patella.⁶ The IS index reliably detects the true but not the pseudo patella baja because the position of joint line is not considered. Instead, the BP and CD indexes count the patellar position relative to the knee joint line and detect both forms: when the joint line shifts proximally, the numerators of these indexes decrease and so do the indexes.³

Incidence of patella baja after primary TKA is about 34–64%.^{1,7} In revision TKA, the pseudo form of patella baja may develop by the proximal shift of joint line, which is common for various reasons.^{8–10} The bone loss at distal femur in revision surgery is usually profound; therefore, the femoral component is undersized. The use of a straight diaphyseal fixation stem tends to put the femoral component anteriorly and create a large posterior (flexion) space;

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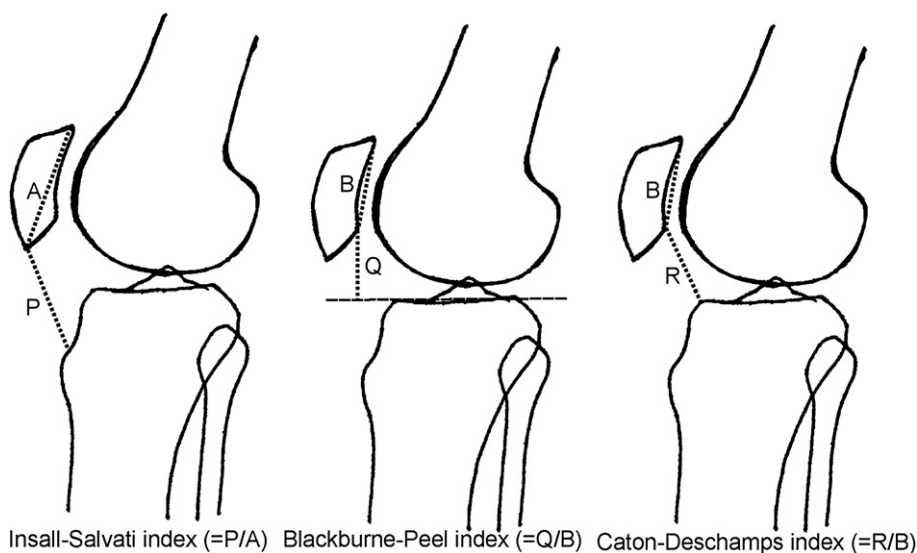


Fig. 1. Three indexing methods to define patellar height on the plain lateral radiograph. A = diagonal length of patella, B = length of articular portion of patella, P = length of patellar tendon, Q = distance between the lower pole of patellar articular surface and the extended line of tibial plateau, R = distance between the lower pole of patellar articular surface and the anterior border of tibial plateau. See text for details.

therefore, surgeons may install the femoral component more proximally to create a larger distal (extension) space to balance these two spaces. We hypothesized that a considerable proportion of patella baja after revision TKA would be the pseudo form.

Whether patella baja affects the outcome of TKA is controversial. Reported influences include pain, impingement, and restriction of knee motion.^{11–13} Shortening of the patellar tendon after primary TKA by more than 10% the original length will associate with restriction of knee flexion, presumably because of the reduction in the length of extensor apparatus.¹ More serious consequences of post-TKA patella baja include the impingement of the patella against the tibial polyethylene or metal plate, anterior knee pain, increased energy expenditure, and rupture of the patellar or quadriceps tendons.¹⁴ However, another report showed that patella baja had no influence on the range of motion or power of the quadriceps muscle.⁷ Change of the joint line can negatively affect the surgical outcome of primary TKA by the correlation with restricted range of motion, anterior knee pain, and poorer knee score, in some reports.^{4,11} However, later studies on revision TKA failed to find such a correlation.^{8,9} This study investigated the relationship of patella baja and the extent of knee flexion.

This study investigated the incidence of patella baja after revision TKA and the influence of patella baja on surgical outcome.

2. Methods

This is a cohort study conducted under approval of the institutional review board of the hospital to investigate the incidence and effects of patella baja after revision TKA. The inclusion criterion was a failed primary TKA that needed revision, though the patient was able to walk and had adequate quadriceps strength to actively extend the knee

joint. We excluded the patients of stiff primary TKA with the maximal flexion less than 20°, patients with prosthetic hip replacement, patients with history of ipsilateral patellar fracture, and patients who received total patellectomy. After the revision surgery, patients with significant bone loss at the proximal fibula such that the shape of fibular head could not be defined on plain radiograph were also excluded. Informed consents were signed by every enrolled patient before the surgery.

Totally, 29 revision TKA in 25 patients (20 women and 5 men) were collected, with an average age of 75 (range, 60–85) years at the revision surgery. The reasons for revision included aseptic loosening (20 knees), infection (8 knees), and malposition of prosthesis (1 knee). All surgeries were done by the same surgeon to replace the original prosthesis of various brands and designs with constrained condylar knee prosthesis (NexGen LCKK, Zimmer, Warsaw, IN, USA) through a standard medial parapatellar arthrotomy. For patients without infection in the failed primary TKA, joint line of the primary prosthetic knees was marked with stitches on the collateral ligaments before the removal of implants. After complete retrieval of the original implants, new prostheses were installed immediately in the same surgery. For patients with infected primary TKA, the original implants were removed 6 months before the revision surgery. Intravenous antibiotics were administered during the prosthesis-absent period.

The patella position, angle of maximal flexion of the knee joint, and joint line position were recorded before the revision surgery and at the postoperative follow-ups. The patella position was observed on the plain lateral radiograph with the knee in 20° flexion and used to determine the IS, BP, and CD indexes. The measurements for the latter two indexes were modified in prosthetic knees¹⁵ because these indexes were originally designed for native knees. The joint line for BP index was the tangential

line perpendicular to the longitudinal axis of tibia and through the most anterosuperior point of the polyethylene insert of the prosthesis, a point that was readily identified on the lateral radiograph. The patellotibial distance in CD index also referred to this point (Fig. 2). The definitions of patella baja by the indexes were as follows: IS index <0.8 , BP index <0.5 , and CD index <0.6 . The angles of maximal flexion were measured directly with a goniometer. The joint line position was the distance of the joint line, as described in the measurement of BP index, above the proximal end of the fibular head on the plain lateral radiograph. All these measures were done by an independent investigator blind to the patients' information and surgery. Average period of follow-up was 28.3 (range, 21–81) months.

To research the possible factors affecting the postoperative knee motion, we evaluated the correlation of the knee motion at last follow-up with the postoperative patella position, postoperative joint line position, and preoperative knee motion. We calculated the correlation coefficients between the maximal flexion angle at last follow-up and (1) the three indexes at last follow-up, (2) the joint line position at last follow-up, and (3) the preoperative maximal flexion angle, respectively with linear regression. The coefficient closer to the value 1 indicated the higher correlation between the two variables.

The effect of surgery on patella position was analyzed by comparing the preoperative and postoperative IS indexes, and joint line positions, with paired *t* test, setting significant difference at $p < 0.05$. The influence of patella position on knee motion was analyzed by comparing the mean maximal flexion angle of knees with and without the IS index-defined patella baja.

Because the revision protocol for infected primary TKA differed from that for aseptic cases, we compared the mean

of maximal flexion angle and the three indexes between these two groups to see the effect of infection on the outcome of revision arthroplasty.

3. Results

At last follow-up, the IS index ranged from 0.47 to 1.26 (mean, 0.78) and defined 17 knees (58.7%) as patella baja. The BP index ranged from -0.54 to 1.06 (mean, 0.18) and defined 24 knees (82.6%) as patella baja. The negative values of this index indicated that the inferior pole of the patellar articular surface lay below the knee joint line, as found in eight knees. The CD index ranged from 0.05 to 1.09 (mean, 0.34) and defined 26 knees (89.7%) as patella baja. The BP and CD indexes defined more patella baja than the IS index did. All IS index-defined patella baja was also defined so by the other two indexes.

At last follow-up, the maximal flexion angle ranged from 70° to 130° (mean, 95.5°). This maximal flexion angle had the correlation coefficients of -0.06 with IS, -0.21 with BP, and -0.14 with CD indexes. All three sets showed weak correlation, indicating that the extent of knee motion was irrelevant to the patellar position. The maximal flexion angle had a correlation coefficient of 0.12 with joint line position, which also showed a weak correlation. However, this maximal flexion angle had moderate correlation with the preoperative maximal flexion angle, at a coefficient of 0.52.

The mean IS index was 0.82 before and 0.78 after the surgery, with significant difference. However, the joint line position was 14.96 mm before and 16.27 mm after the surgery, without significant difference ($p = 0.11$ with a power of 0.23).

At last follow-up, the mean maximal flexion angle was 97.9° in the 17 IS index-defined patella baja knees and 92.1°

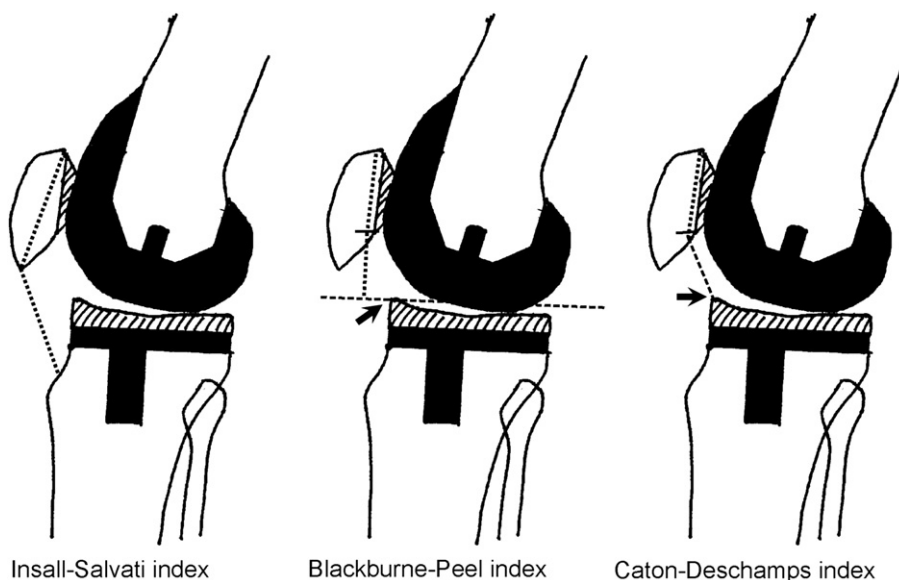


Fig. 2. Modification of the three patellar height indexes for the prosthetic knees. In the Blackburne-Peel index, the tibial plateau line was substituted with a tangential line perpendicular to the longitudinal axis of tibia and through the most anterosuperior point of the polyethylene insert of the prosthesis (arrows). This point of the polyethylene insert also served as the reference point of the patellotibial distance in Caton-Deschamps index.

in the other 12 knees. These two values had no significant difference ($p = 0.23$ with a power of 0.097).

The outcome of revision TKA for infected primary surgery and aseptic loosening of the implant was shown in Table 1. None of these parameters had significant differences between the two groups.

4. Discussion

Both the true and pseudo forms of patella baja develop after revision TKA. The IS index detects only the true form, while the BP and CD indexes detect both forms. Therefore, the latter two indexes may determine more patella baja than the IS index does, in the same group of patients. The IS index-defined patella baja would be included completely in the patella baja determined by the other two indexes. These theories were held true by our findings. Among our patients, the 17 IS index-defined patella baja were considered the true form. Additionally, the BP index determined seven, and the CD index determined nine pseudo patella baja.

Patella baja and restriction of knee flexion can both occur after revision TKA; however, whether the patella baja affects the knee motion or not has been debated.^{1,11} In our study, we did not find a good correlation between the extent of knee motion and either forms of patella baja. The restricted knee flexion after revision TKA might have resulted from other factors, such as intra-articular adhesions or impingement, extra-articular adhesions, unbalanced flexion-extension space, and inadequate rehabilitation. The shortening of patellar tendon after knee arthroplasty was considered to limit the knee flexion.¹ In our study, the mean maximal flexion angle of patients with shortened patellar tendon, that is, the IS index-defined patella baja did not differ significantly from that of patients without the tendon shortening. We proposed that the shortening of patellar tendon did not significantly alter the length and stiffness of the entire extensor apparatus, consisting of the quadriceps muscles, tendons, and patella bone. The majority of the length of the extensor is soft, easily stretchable muscle, so that the knee flexion would not be strapped from the front.

Nevertheless, surgical insult would result in the shortening of patellar tendon. The mean IS index decreased significantly after the surgery in our study. Both the BP and CD indexes mix the effects of patellar tendon shortening and joint line shift on patella baja. We considered it difficult to interpret the changes of these two indexes around the surgery because we would not be able to decide whether

such changes should be attributed to the alternation of the patellar tendon length, or shift of the joint line position, or both. Therefore, we directly analyzed the joint line position and found no significant change by the surgery. From this we infer that the seven BP index-defined and the nine CD index-defined pseudo patella baja knees had carried the abnormal joint line position before the surgery, and the surgery did not correct this problem. In fact, these knees were also defined as patella baja by these two indexes before the surgery. Because we tried to install the revision prostheses with their joint line position close, if not identical, to that of the primary prosthetic knees during the surgery, it was reasonable that the pseudo patella baja would remain so postoperatively. It has been reported that accurate restoration of the joint line, referring to the normal unaffected opposite knee, can improve the surgical outcome of revision TKA.¹⁶ We did not attempt so to restore the joint line position in this study.

Surgical technique, such as the balancing of flexion and extension gap, in revision TKA is an important determinant of good surgical outcome with deeper flexion.¹⁷ In fact, the revision surgery itself can be a solution for stiff primary TKA.^{18–20} We also found significant improvement of the mean maximal flexion angle by surgery, when the angles were analyzed patient-wisely by paired *t* test (81.2° preoperatively and 95.5° at last follow-up, $p < 0.05$). However, we considered this finding inconclusive on the contribution of surgery to the knee flexion. The reasons for the restriction of flexion in the primary TKA may be very complex and include designs and position of the prostheses, the condition and mass of the periarticular soft tissue, and the diagnosis for the arthroplasty.²¹ Not all of these reasons could be handled with revision surgery; therefore, the contribution of revision surgery to improve knee motion may vary greatly among patients. In addition, the flexion of infected TKA may be much restricted by the active inflammation and swelling of the knee joint. The flexion loss may worsen after removal of the original prosthesis and a period of immobilization of the joint to treat the infection. Precise determination of the maximal flexion angle after removal of the implant was extremely difficult because the knee joint was absent of substantial articulation without the prosthesis. Although the preoperative range of motion is a major determinant for the knee motion after primary TKA,²² it may not be so important in the case of revision surgery.

Infection may lead to patella baja and restricted knee flexion.²³ Infection may result in fibrosis and consequently shortening of the patellar tendon. Prolonged inflammation and immobilization after debridement would lead to intra-articular adhesion that contributes to the restriction of knee flexion. We found more patella baja and poorer knee flexion on the knees revised for infected primary TKA than for aseptic loosening of the implants. Although the differences were not significant, Type II error may exist. At least 37 cases for each group were required for the statistic power of 0.8. A significant difference might be found if more patients were studied.

Interobserver variation may occur in the measurement for the patella height indexes. Although the IS index has the advantage of detecting purely the true patella baja, the

Table 1

Outcome of revision TKA for patients with and without infection of the primary surgery. See text for interpretation.

	Infection (<i>n</i> = 8)	Aseptic loosening (<i>n</i> = 20)	<i>p</i>	Power
Maximal flexion angle	90.6° ± 4.3°	98.3° ± 2.8°	0.16	0.17
IS index	0.70 ± 0.09	0.82 ± 0.04	0.16	0.17
BP index	0.24 ± 0.16	0.19 ± 0.09	0.77	0.05
CD index	0.36 ± 0.11	0.35 ± 0.05	0.93	0.05

TKA = total knee arthroplasty; IS = Insall-Salvati; BP = Blackburne-Peel; CD = Caton-Deschamps.

measurement for this index may have the most interobserver variation among the three indexes.¹⁵ This happens because the measurement refers to the insertion of patellar tendon onto the tibial tuberosity. The insertion is a small area rather than a point; therefore, variation on selecting the insertion site as a point will bias the measurement of patellar tendon length. The BP and CD indexes are more precisely determined, especially on the prosthetic knees where the reference point on the polyethylene insert can be clearly identified on radiograph. In this study, all measurements were done by the same investigator, and all joints concerned were prosthetic, so that the bias of determining these indexes could be minimized.

We concluded that patella baja commonly existed after revision TKA but would not affect knee flexion. A part of these postoperative patella baja was the result of abnormal joint line position, that is, pseudo patella baja, instead of shortening of the patellar tendon.

Acknowledgments

The authors declare that they have no competing interests.

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