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Prevention of pseudo-patella baja during total knee arthroplasty

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Abstract
Purpose Pseudo-patella baja (PPB) is a surgical complication that can arise from total knee arthroplasty and occurs when the patella tendon is not shortened but the level of the femorotibial joint line is elevated. The goal of this study was to assess the performance of a technique specifically designed to prevent the occurrence of PPB and its radiological results.
Methods Ninety-nine patients undergoing total knee arthroplasty were included. Patients were divided into a non-correction group and a correction group. The correction group were applied an additional metal block in order to reduce the excess resection of the distal femur. To evaluate PPB, the change in the pre- and postoperative joint line was measured using the modified Blackburne–Peel Index (BPI).
Results In the non-correction group, 68 of 74 cases showed an occurrence of PPB (92 %), in the correction group, 6 of 57 cases showed an occurrence of PPB (11 %). The preoperative-modified BPI of the non-correction group was not significantly different from that of the correction group (0.6 ± 0.1 vs. 0.6 ± 0.2). The modified BPI decreased significantly in the non-correction group after TKA (0.6 ± 0.1 vs. 0.2 ± 0.1, $p < 0.05$). However, the modified BPI did not change significantly in the correction group after TKA (0.6 ± 0.2 vs. 0.6 ± 0.2).
Conclusion The comparison of preoperative and postoperative radiological results showed that our intervention maintained the joint line without elevation. We proposed an effective method to prevent various complications due to the joint line elevation that occur in PPB.
Level of evidence III.

Keywords Patella · Total knee arthroplasty · Complication

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Introduction

Restoration of joint line level is a common goal of total knee arthroplasty, and management of the joint line level is critical when restoring ligamentous balance and normal knee kinematics [1]. Positional changes such as movement of the femorotibial joint line toward the patella can occur on total knee arthroplasty. Such a change in the patella due to joint line elevation is known as pseudo-patella baja (PPB). PPB occurs when the femorotibial joint line rises without a change in the length of the patellar tendon, often as a result of the use of a thick polyethylene insert during excess distal femoral bone resection and excess soft tissue release. The incidence of PPB after total knee arthroplasty has been reported as 21–47 % in previous studies [14]. As PPB is associated with joint line elevation and results in decreased range of motion, anterior knee pain, and patellar component impingement on the tibia or the polyethylene, it is critical to maintain a normal joint line level during total knee arthroplasty. Few studies have investigated the role of the joint line in the final

outcome of total knee arthroplasty, and most of these have concentrated on the revision situation. There are no studies that have evaluated the restoration of the joint line during primary total knee arthroplasty. Restoration of the joint line is determined by the accuracy of the operative technique, the instruments used, and the prosthesis design. As current operative techniques have a tendency to elevate the joint line, some reports have suggested that alterations should be made to allow exact joint reconstruction in the preoperative setting. The height of joint line is determined by the level of distal femoral resection during total knee arthroplasty, and PPB occurs when excess distal femoral bone is resected [14]. To prevent PPB, new surgical technique needs to be developed. It was hypothesized that the incidence of the PPB may be reduced by reducing distal femoral bone excess resection. To reduce distal femoral bone resection, the correction group were applied an additional metal block between the distal femoral block and distal femur part. Furthermore, the preventive effect of this technique on PPB was evaluated. The present study was designed to evaluate the preventive effect of PPB using new correction technique with additional metal block on total knee arthroplasty, and assessed the joint line elevation in radiological results.

Materials and methods

This study included 131 cases in 99 patients treated with total knee arthroplasty from 2011 to 2012. Patients were divided into a non-correction group and a correction group. Data were collected prospectively. The study complied with the Declaration of Helsinki and was approved by the Institutional Review Board of the Samsung medical center. The IRB number is 2012-09-093-001.

Written consent was obtained from all patients. Seventy-four cases in 53 patients were included in non-correction group, without the application of additional metal block between the distal femoral block and distal femur part (the joint line elevation was not corrected). Fifty-seven cases in 46 patients were included in the correction group, with the application of additional metal block between distal femoral block and distal femur part to reduce the distal femoral bone resection (the joint line elevation was corrected). Low patella height at preoperative evaluation or excessive collateral ligament laxity can cause joint line elevation after total knee arthroplasty and further lower the position of the patella. We selected the correction group based on the following criteria. The mean length of the articular surface of the patella of our patients was 33.3 mm ± 3.2. The perpendicular height from the plateau line of the tibia to the lower end of the patellar articular surface within 15 mm (33.3 mm × 0.5, lower normal range of modified BPI) was regarded as low patella height selected for correction. Laxity of lateral collateral ligament leads to an increased gap during bone cutting. It has been previously reported that the difference in length of collateral ligament never exceeds 2–3 mm during strained and relaxed positions [6]. Accordingly, excessive collateral ligament laxity was defined as the length of collateral ligament of >4 mm on valgus and varus stress positions of knee joint stress radiograph; this group was also selected for correction. Cases other than the above two criteria were included in the non-correction group. All patients underwent total knee arthroplasty using an extramedullary minimal invasive surgical technique [24], and the same type of prosthesis (Lospa Knee® System, Corentec, Korea) was fitted. The correction method used to reduce distal femoral bone resection involved additional application of a 4-mm-thick metal block at the distal femoral block (Fig. 1). In order to measure the changes of relationship between patellar height and joint line, radiograph imaging of the lateral view of the knee joint in full extension while weight bearing was taken before and after surgery. To minimize bias during imaging, a neutral position by maintaining the same foot location was measured. The PACS system (Centricity Enterprise Web version 3.0, GE Medical Systems, Milwaukee, WI, USA) was used for all radiologic viewing of preoperative and postoperative images in the lateral view, on two separate monitors. Measurements were recorded up to one decimal point. The modified Blackburne–Peel Index (BPI) was used to evaluate changes in relationship between the patellar height and joint line. Modified BPI was measured on knee joint extension because this allowed for better gross views of the relationship between the joint line and the alta and baja positions of the patella (Fig. 2). A significant correlation was observed between the BPI at 30° of flexion and full extension when comparing the two groups using Pearson's correlation coefficient ($r = 0.86$, $p < 0.05$) (Fig. 3). The normal range using the classic BPI is 0.5–1.1 [4], whereas the normal modified BPI range is 0.5–0.9 with reference to the classic index. The perpendicular height from the plateau line of the tibia to the lower end of the patellar articular surface, divided by the length of the articular surface of patella [4], each of which were measured from the lateral X-ray view, was quantified using the modified BPI to reflect a change in relationship between the patellar height and the joint line. To minimize the inter-observer variation, two blind observers measured the BPI in the radiograph.

Statistical analysis

The primary end point of this study was the evaluation of the preventive effect of PPB incidence following total knee arthroplasty. The incidence of PPB after total knee arthroplasty has been reported as 33.4 ± 11.9 % in different studies [14]. It was hypothesized that the incidence PPB would be 23.4 ± 11.9 % in patients selected to a correction group

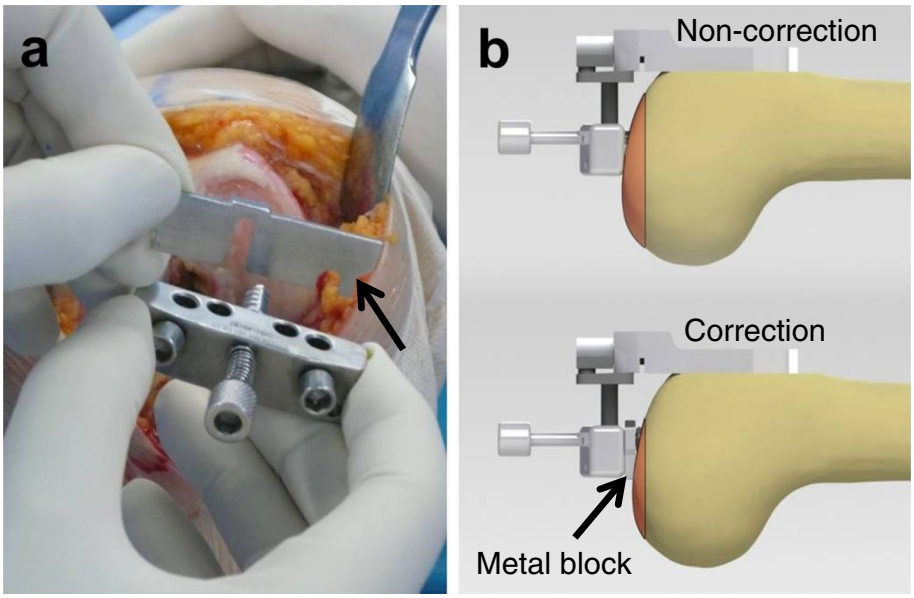

Fig. 1 **a** Correction group were applied an additional metal block (figure *arrow*) between the femoral block and distal femur part. **b** Comparison of the distal femoral resection level between the non-correction and correction group. Correction group applied the additional 4-mm-thick metal block (figure *arrow*) to make further distal the joint line and reduce the excess resection of distal femur (figure, *red bone part*)

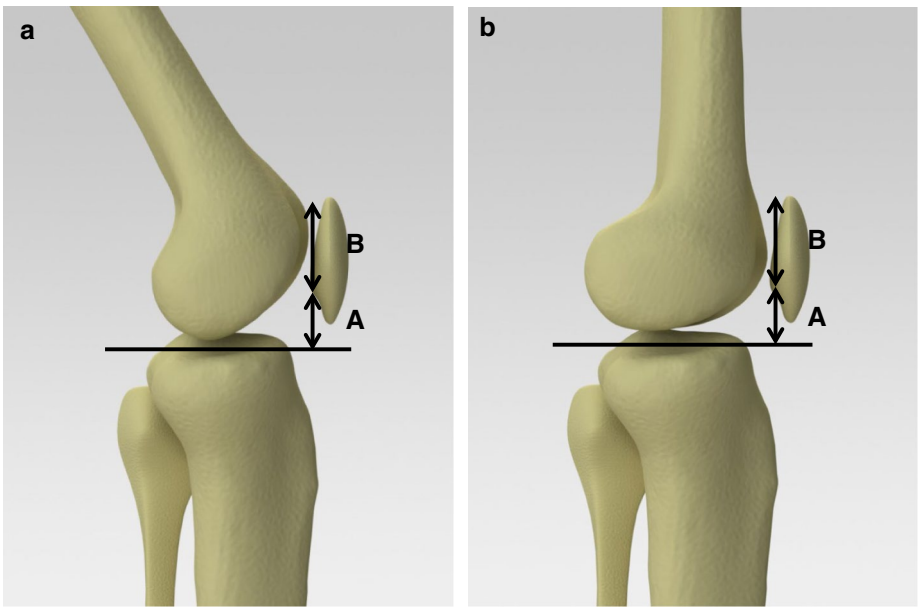

Fig. 2 **a** Thirty degree flexion BPI, **b** Modified BPI (extension BPI). BPI is defined *A* to *B* ratio (*A* length divided by *B* length). *A* The perpendicular height from the plateau line of the tibia to the lower end of the patellar articular surface; *B* the length of the articular surface of patella

with metal block. Therefore, at least 28 patients in each group would be required to provide a power of 80 % to detect statistical differences between groups with a 2-sided α level of 0.05. The paired *t* test was used to compare preoperative- and postoperative-modified BPI to assess the differences in the incidence of PPB. All statistical analyses were performed with SPSS version 12.0 (SPSS Inc, Chicago, IL, USA).

Results

Seventy-four cases in 53 patients were included in the joint line elevation non-correction group, and 57 cases in 46 patients were included in the joint line elevation correction group. The non-correction group included 6 males and 68 females with an average age of 71.7 ± 6.4 years. The correction group included 4 males and 53 females with an average age of 71.2 ± 6.9 years. No significant differences in age, sex, or preoperative diagnosis were observed between the two groups (Table 1). An analysis of both groups was conducted preoperatively and postoperatively based on the normal range (0.45–0.89) of the modified BPI. For the preoperative measured values in the non-correction group, 3 of 74 cases had values above the normal range, 66 of 74 cases were within the normal range, and 5 of 74 cases had values below the normal range. For the

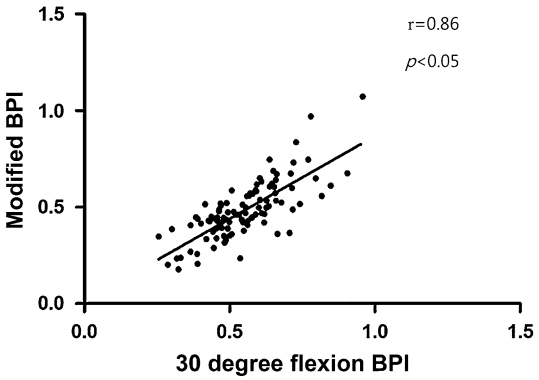

Fig. 3 Correlation between 30° flexion BPI and modified BPI (extension BPI). Pearson's correlation coefficient ($r = 0.86$, $p < 0.05$)

postoperative measured values in the non-correction group, no cases had values over the normal range, 6 of 74 had values within the normal range, and 68 of 74 cases had values below the normal range. For the preoperative measured values in the correction group, 1 of 57 cases had values above the normal range, 45 of 57 cases had values within the normal range, and 11 of 57 cases had values below the normal range. For the postoperative measured values in the correction group, 1 of 57 cases had values above the normal range, 50 of 57 cases had values within the normal range, and 6 of 57 cases had values below the normal range (Table 2). In the non-correction group, 68 of 74 cases had occurrence of PPB (92 %), in the correction group, 6 of 57 cases had occurrence of PPB (11 %) (Table 3). The modified BPI results showed no significant difference in preoperative indices between the non-correction and correction groups (0.6 ± 0.1 vs. 0.6 ± 0.2). However, a comparison of the postoperative indices revealed significant differences between the non-correction and correction groups (0.2 ± 0.1 vs. 0.6 ± 0.2, $p < 0.05$) (Table 4). Moreover, modified BPI tended to be reduced in postoperative joint line elevation. A significant decrease from preoperative- to postoperative-modified BPI was observed in the non-correction group (0.6 ± 0.1 vs. 0.2 ± 0.1, $p < 0.05$), but no significant difference was observed in the correction group (0.6 ± 0.2 vs. 0.6 ± 0.2) (Fig. 4).

Discussion

In this study, it was demonstrated that the application of an additional metal block between the distal femoral block and distal femur part reduced the occurrence of PPB. The postoperative-modified BPI in the correction group did not change significantly, indicating preservation of the joint line.

Joint line level is usually measured by the distance from one of the anatomical landmarks. Iacono et al. [12] reported that the adductor tubercle can be used as a morphologic landmark to determine the knee joint line position, and Bellemans [3] explained that the normal joint line lies approximately 25 mm distal to the medial femoral epicondyle and 10 mm proximal to the fibular head. However, these methods lack an explanation for the relationship between the patella height and joint line of knee. In this study, therefore, modified BPI method was used to examine the relationship between the patella height and joint line of knee.

BPI is universally measured from lateral radiographs with the knee in a standardized flexed position. However, a good correlation exists between preoperative and postoperative BPI measured without holding the knee in a standardized flexed position [25]. Therefore, in this study, we

Table 1 Demographic factors

	Non-correction group ($n = 74$)	Correction group ($n = 57$)	p value
Age (years)	71.7 ± 6.4	71.2 ± 6.9	n.s
Female (n)	68	53	n.s
Male (n)	6	4	n.s
Diagnosis (osteoarthritis) (n)	74	57	n.s
Bilateral TKA (n)	21	11	n.s
Unilateral TKA (n)	32	35	n.s

Table 2 Preoperative and postoperative comparison of groups according to the normal range of the modified BPI

Modified BPI	Non-correction group ($n = 74$)		Correction group ($n = 57$)	
	Pre-op.	Post-op.	Pre-op.	Post-op.
Above normal (n)	3	0	1	1
Normal (n)	66	6	45	50
Below normal (n)	5	68	11	6

Table 3 Incidence of PPB in the non-correction group and the correction group

	Non-correction group	Correction group
PPB incidence (%)	92	11

Table 4 Preoperative and postoperative mean measured values of the modified BPI

	Non-correction group	Correction group	*p* value
Pre-op-modified BPI	0.6 ± 0.1	0.6 ± 0.2	n.s
Post-op-modified BPI	0.2 ± 0.1	0.6 ± 0.2	<0.05

replaced the classic BPI, in which the knee joint is held in a 30° flexed position, with a modified BPI, which utilizes a fully extended knee position to evaluate joint line elevation. When evaluated using a normal range of the modified BPI, the results revealed a 92 % incidence of PPB in the non-correction group and an 11 % incidence in the correction group. Thus, the use of this technique to correct joint line elevation during total knee arthroplasty reduced the prevalence of PPB.

It was reported that about 11 % of patients occurred the anterior knee pain after routine patella replacement with total knee arthroplasty [17]. Joint line elevation after total knee arthroplasty can lead to a decreased range of motion, and restoration of the proper joint line is a major factor for successful total knee arthroplasty [9, 11, 15, 18, 23]. Badazadeh et al. [2] reported that joint line elevation occurs not only in cases of revision total knee arthroplasty but also in primary total knee arthroplasty and that the position of the articular surface is associated with knee joint function. Kazemi et al. [14] explained that PPB often occurs after total knee arthroplasty and is related to decreased range of motion and increased knee pain. Figgie et al. [9] concluded that patella baja induced by joint line elevation after total knee arthroplasty is associated with knee pain and a decrease in knee function. Similarly, Chonko et al. [5] reported that patella baja caused by joint line elevation after total knee arthroplasty is likely to result in anterior knee pain, decreased range of motion, and patella component impingement on the tibia or the polyethylene. In addition, Goldberg et al. [10] stated that changes in the joint line after total knee arthroplasty can cause serious problems. Martin and Whiteside [16] explained that when the postoperative joint line is well preserved relative to the preoperative condition, stability is preserved. Estupinan et al. [8] claimed that a shift in the joint line itself induces wear of the polyethylene, and Rand [20] suggested that greater proximal joint line shifts correspond to more distal patella movement, compared to the preoperative position. Our study also reported that the more the joint line elevated, the more distal the patella shifted, resulting in a reduction in the modified BPI.

Because PPB negatively impacts the postoperative function of the knee joint, an efficient method to prevent joint line elevation is necessary. We implemented an additional application of a metal block at the distal femoral block via preoperative evaluation to prevent PPB and developed a technique to minimize distal femoral bone resection. Kawamura et al. [13] reported an average postoperative joint line elevation of 3.5 mm; Sabbioni et al. [21] reported an average postoperative elevation of 4 mm; Scuderi and Insall [22] reported an average postoperative elevation of 5.6 mm. The results of these studies aided in the formulation of a correction plan for joint line elevation. A metal block thicker than 4 mm at the distal femoral block could lead to inappropriate resection of the distal femur, hence a thickness of 4 mm was chosen. We found that the additional application of a metal block at the distal femoral block helped maintain the joint line postoperatively.

Joint line elevation indicates distal shift of the patella, increasing not only the pressure on the patella when

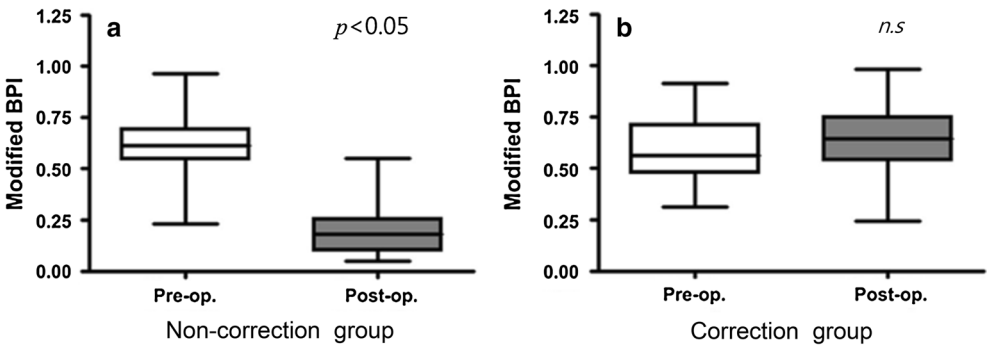

Fig. 4 **a** Modified BPI was significantly decreased in the non-correction group (0.6 ± 0.1 vs. 0.2 ± 0.1, $p < 0.05$). **b** Modified BPI did not significantly change in the correction group after TKA (0.6 ± 0.2 vs. 0.6 ± 0.2, n.s)

flexed, but also tension on the soft tissue [10, 20]. Partington et al. [18] reported that joint line elevation of >8 mm yields inferior clinical results, and Porteous et al. [19] found that joint line elevation of >5 mm worsened clinical outcomes. Emodi et al. [7] suggested that even mild joint line elevation of <2 mm alters the transmission of myogenic strength in the quadriceps and increased patellafemoral pressure forces. Restoration of the proper joint line is critical to prevent PPB due to joint line elevation, which plays an important role in successful total knee arthroplasty.

Several limitations of the present study should be noted. This study was not a double-blind study, and only a small number of patients were enrolled. The possibility of selection bias must be considered when interpreting our findings. This study simply demonstrated the radiologic properties of new correction technique, without clinical data. There needs to be further investigation on clinical outcome of this new surgical technique. Knee score such as Knee society score and Western Ontario and McMaster Universities Arthritis Index will be evaluated for a comparison between correction and non-correction groups.

Conclusions

PPB is often overlooked, but there exists a common complication of joint line elevation in total knee arthroplasty. In this study, adding a metal block at the distal femoral block was implemented to minimize distal femoral bone resection via preoperative planning. The comparison of preoperative and postoperative radiological results showed that our intervention maintained the joint line without elevation. In conclusion, adding a metal block at the distal femoral block is a useful method for preventing PPB. To confirm the effect of this correction method, replication studies with larger populations are needed.

References

1. Anagnostakos K, Lorbach O, Kohn D (2012) Patella baja after unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 20:1456–1462
2. Babazadeh S, Dowsey MM, Swan JD, Stoney JD, Choong PF (2011) Joint line position correlates with function after primary total knee replacement: a randomised controlled trial comparing conventional and computer-assisted surgery. J Bone Joint Surg Br 93:1223–1231
3. Bellemans J (2004) Restoring the joint line in revision TKA: does it matter? Knee 11:3–5
4. Blackburne JS, Peel TE (1977) A new method of measuring patellar height. J Bone Joint Surg Br 59:241–242
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. Delport H, Labey L, De Corte R, Innocenti B, Vander Sloten J, Bellemans J (2013) Collateral ligament strains during knee joint laxity evaluation before and after TKA. Clin Biomech (Bristol, Avon) 28:777–782
7. Emodi GJ, Callaghan JJ, Pedersen DR, Brown TD (1999) Posterior cruciate ligament function following total knee arthroplasty: the effect of joint line elevation. Iowa Orthop J 19:82–92
8. 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 16:80–88
9. Figgie HE 3rd, Goldberg VM, Heiple KG, Moller HS 3rd, Gordon NH (1986) The influence of tibial-patellofemoral location on function of the knee in patients with the posterior stabilized condylar knee prosthesis. J Bone Joint Surg Am 68:1035–1040
10. Goldberg VM, Figgie HE 3rd, Figgie MP (1989) Technical considerations in total knee surgery. Management of patella problems. Orthop Clin North Am 20:189–199
11. Hofmann AA, Kurtin SM, Lyons S, Tanner AM, Bolognesi MP (2006) Clinical and radiographic analysis of accurate restoration of the joint line in revision total knee arthroplasty. J Arthroplasty 21:1154–1162
12. Iacono F, Lo Presti M, Bruni D, Raspugli GF, Bignozzi S, Sharma B, Marcacci M (2013) The adductor tubercle: a reliable landmark for analysing the level of the femorotibial joint line. Knee Surg Sports Traumatol Arthrosc 21:2725–2729
13. Kawamura H, Bourne RB (2001) Factors affecting range of flexion after total knee arthroplasty. J Orthop Sci 6:248–252
14. 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:CR292–CR296
15. Laskin RS (2002) Joint line position restoration during revision total knee replacement. Clin Orthop Relat Res 404:169–171
16. 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
17. Meftah M, Jhurani A, Bhat JA, Ranawat AS, Ranawat CS (2012) The effect of patellar replacement technique on patellofemoral complications and anterior knee pain. J Arthroplasty 27(1075–1080):e1071
18. Partington PF, Sawhney J, Rorabeck CH, Barrack RL, Moore J (1999) Joint line restoration after revision total knee arthroplasty. Clin Orthop Relat Res 367:165–171
19. Porteous AJ, Hassaballa MA, Newman JH (2008) Does the joint line matter in revision total knee replacement? J Bone Joint Surg Br 90:879–884
20. Rand JA (1990) Patellar resurfacing in total knee arthroplasty. Clin Orthop Relat Res 260:110–117
21. Sabbioni G, Rani N, Del Piccolo N, Ben Ayad R, Carubbi C, Tigani D (2011) Gap balancing versus measured resection technique using a mobile-bearing prosthesis in computer-assisted surgery. Musculoskelet Surg 95:25–30
22. Scuderi GR, Insall JN (1992) Total knee arthroplasty. Current clinical perspectives. Clin Orthop Relat Res 276:26–32
23. Selvarajah E, Hooper G (2009) Restoration of the joint line in total knee arthroplasty. J Arthroplasty 24:1099–1102
24. Seo JG, Moon YW, Lim JS, Park SJ, Kim SM (2012) Mechanical axis-derived femoral component rotation in extramedullary total knee arthroplasty: a comparison between femoral transverse axis and transepicondylar axis. Knee Surg Sports Traumatol Arthrosc 20:538–545
25. Wyss TF, Schuster AJ, Munger P, Pfluger D, Wehrli U (2006) Does total knee joint replacement with the soft tissue balancing surgical technique maintain the natural joint line? Arch Orthop Trauma Surg 126:480–486