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No shortening of the patellar tendon during two-stage total knee arthroplasty revision using articulating spacers

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Abstract

Background Surgical techniques in two-stage revision total knee arthroplasty (rTKA) include the use of articulating spacers and static spacers. Shortening of the patellar tendon could be a reason for inferior functional outcomes in two-stage septic rTKA . The aim of this study was to determine if articulating spacers also have negative effects on the extensor mechanism in rTKA.

Methods This retrospective study includes 65 consecutive patients (23 women, 42 men, age 71.3 ± 1.2; range, 51.2–88.6 years) undergoing septic two-stage rTKA using an articulating spacer between 2014 and 2021 in a single orthopedic center. For all patients, calibrated true lateral radiographs before total knee arthroplasty (TKA) explantation (T0), directly after TKA explantation (T1), shortly before TKA reimplantation (T2) and 6–8 days after TKA reimplantation (T3) were used to calculate the modified Insall Salvati ratio (mISR).

Results Overall, the mISR decreased significantly immediately after explantation (T0 vs. T1, $p = 0.002$) from 1.43 ± 0.03 to 1.36 ± 0.03 and remained stable until T2 (1.37 ± 0.02, p = 0.74). Following TKA reimplantation, the mISR increased again to 1.43 ± 0.03 (T3). There were no significant differences between T0 and T3 ($p = 0.88$). Six out of 65 patients (9%) experienced patellar tendon shortening > 10% at T3.

Conclusions Septic two-stage revision TKA using an articulating spacer does not lead to patellar tendon shortening in the majority of cases. This study suggests that one reason for the improved range of motion after reimplantation may be the use of articulating spacers compared to static spacers. *Keywords: revision total knee arthroplasty*, *articulating spacer*, *infection*, *PJI*, *two-stage revision*, *revision arthroplasty*, *patellar tendon*,

Keywords Revision total knee arthroplasty · Articulating spacer · Infection · PJI · Two-stage revision · Revision arthroplasty · Patellar tendon

Introduction

Periprosthetic joint infection (PJI) has a low incidence of 0.5–2% in primary total knee arthroplasties (TKA) [1, 2], but remains one of the most frightening complications [3]. In revision total knee arthroplasty (rTKA) the incidence is even higher, with up to 4% [1]. PJI is the second most frequent reason for rTKA after aseptic loosening, with approximately 25% of revision causes [3]. Although treatment of PJI generally requires surgical revision and antimicrobial therapy based on the length of infection and the organism that causes PJI, various surgical techniques exist. For acute hematogenous and acute postoperative PJIs, debridement, antibiotics, and implant retention (DAIR) is a valuable treatment option. For chronic PJIs, two-stage rTKA still remains the gold standard [4]. First introduced by Insall et al. in 1983, two-stage rTKA for PJI was seen to be very effective and included a six week antibiotic therapy interval already [5]. In the early 2000s the use of articulating and static antibiotic loaded spacers surged and remained the favored techniques to date [3, 4, 6–10]. Although the literature state similar reinfection rates for the two surgical approaches [3], clinical outcomes are reported to be inferior in patients with static spacers [11–14]. Kirschbaum et al.

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Table 1 Patient demographic data. The data are presented as mean ± SD [range]

	Study population ($n = 65$)
Age [years]	71.3 ± 9.3 [51–89]
Sex [female: male]	23:42
Affected leg [right; left]	34:31
Number of previous knee surgeries	1.46 ± 0.79 [1–5]
CRP [mg/dl] at G0	56.3 ± 78.98 [0-381]
Duration of interval [days]	73 ± 29.3 [18–190]

stated that the reason for inferior range of motion in patients who underwent two-stage rTKA using static spacers might be due to patellar tendon shortening [15]. This patellar tendon shortening could lead to persistent pain and diminished functional outcomes after rTKA, which are two of the main concerns following this procedure.

There is no known data regarding the use of articulating spacers in two-stage revision TKA and their association with possible patellar tendon shortening. We hypothesize that due to the possible motion allowed by the articulating spacers during the interval, there is no patellar tendon shortening after reimplantation. Consequently, these patients might have better clinical outcomes.

The aim of this present study was to determine whether articulating spacers are associated with patellar tendon shortening in revision TKA or if they don't lead to patellar tendon shortening.

Materials and methods

This retrospective study includes 65 consecutive patients (Tables 1 and 23 women, 42 men, age 71,3 ± 1.2; range, 51.2–88.6 years) undergoing septic two-stage rTKA using an articulating spacer for PJI between 2014 and 2021 in a single orthopedic center. The explantation surgeries were performed by 6 experienced orthopedic surgeons, while reimplantation was performed by 3 experienced surgeons.

The study protocol was approved by the local ethics committee (approval number: 2022-203-BO-ff). Patient data for this study were obtained from the institutional database. Demographic and patient related measures included age, sex, initial serum CRP levels at T0, previous implant, time from primary TKA to rTKA. Radiographic measurements were performed using IntelliSpace PACS, Version 4.4 (Philips, Amsterdam, Netherlands).

Inclusion and exclusion criteria

The inclusion criteria were presence of chronic PJI after TKA and two stage revision using articulating spacers. Patients who underwent more than two stages, periprosthetic joint fractures, tibial tuberosity osteotomy in any stage and extensor mechanism lesions were excluded from this study.

Fig. 1 New femoral component and tibial polymethylmethacrylate (PMMA) spacer prepared for implantation

Surgical technique

The technique is originally based on Hofmann et al. [8]. However, within our institution, we adapted and modified this technique. At first stage surgical technique included the complete removal of prosthetic components and cement, debridement of bone and soft tissues, while preserving the collateral ligaments. Subsequently, a tibial component spacer is made from polymethylmethacrylate (PMMA) cement using a mold, loaded with vancomycin and gentamycin (Fig. 1). Following that, the spacer was carefully placed onto the tibia, and a new femoral component (NFC) was introduced onto the femur without the use of cement (Fig. 2). For all patients reimplantation was scheduled within 6 to 12 weeks after first stage depending on infection situation. At second stage the explantation of the NFC, the tibial cement spacer and debridement of soft tissue was performed. A new TKA was then implanted. Weight-bearing as tolerated with the requirement for supportive devices if necessary was allowed between the stages. After reimplantation full weight bearing was allowed.

Radiographic measurements

For all patients, calibrated true lateral radiographs taken before TKA explantation (T0), directly after TKA explantation (T1), shortly before TKA reimplantation (T2), and 6–8 days after TKA reimplantation (T3) were used to calculate

Fig. 2 Anterior-posterior radiograph after the first-stage surgery showing the mobile spacer in place

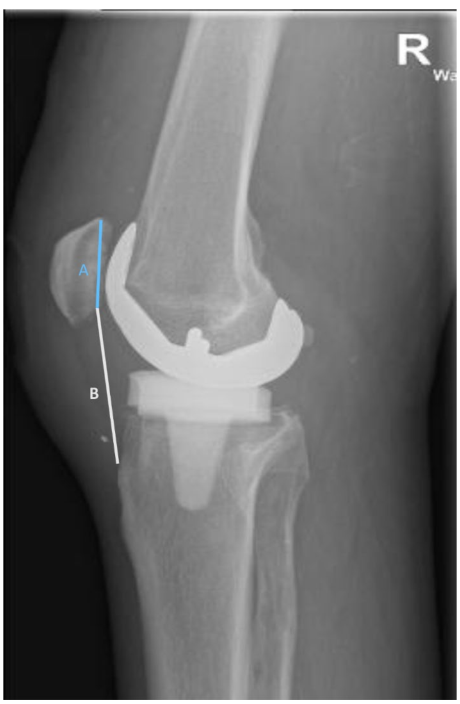

Fig. 3 Measurement of the modified insall Salvati ratio (mISR): the distance between (**B**) the tibial tuberosity and the most distal patellofemoral articulation point and (**A**) the longitudinal diameter of the articulating surface of the patella

the modified Insall-Salvati ratio (mISR) (Fig. 3). Two experienced observers (N.M. and O.T.) independently evaluated all radiographs. These observers were not involved in the treatment of the included patients. All radiographic measurements were performed using IntelliSpace PACS, Version 4.4 (Philips, Amsterdam, Netherlands). The mISR was calculated as the ratio of the distance between the tibial tuberosity and the most distal patellofemoral articulation point (B) to the longitudinal diameter of the articulating surface of the patella (A) (Fig. 3) [16]. An mISR above 2 indicates a patella alta, while an mISR below 1.2 indicates a patella baja [17]. Significant patellar tendon shortening is generally considered to be a shortening of more than 10% [15]. Therefore, this subgroup was further analyzed for patients with a patellar tendon difference exceeding this threshold between all stages to account for possible measurement inaccuracies.

Statistical analysis

Statistical analysis was performed using SPSS, Version 27 (SPSS Inc., Chicago, IL, USA). Continuous variables are expressed as mean ± standard error of mean (SEM) and range, while categorical variables are expressed as number and percentage (%).

The comparison of parametric data was performed with a t-test, and nonparametric data were tested by a Wilcoxon signed rank test. Normal distribution was examined using the Shapiro-Wilk test. The interrater reliability was assessed using Cronbach's alpha to evaluate the intraclass correlation coefficient (ICC), following the interpretation guidelines provided by Landis and Koch: ICC values below 0.2 indicate slight agreement, 0.21-0.40 represent fair agreement, 0.41-0.60 correspond to moderate agreement, 0.61-0.80 suggest substantial agreement, and values greater than 0.81 indicate almost perfect agreement. P-values <0.05 were considered significant.

Results

We observed a significant decrease in the mISR immediately after explantation (T0 versus T1, $p=0.002$), with values shifting from 1.43 ± 0.03 to 1.36 ± 0.03. There was no significant change in mISR between T1 and T2 ($p=0.737$). Following reimplantation, the mISR increased again to 1.43 ± 0.03 (T3). Notably, there were no significant differences in the mISR observed, when comparing patella height between T0 and T3 ($p=0.876$) (Fig. 4).

Interobserver reliability (ICC) was 0.90 for radiographic measurements and 0.98 for resulting mISR.

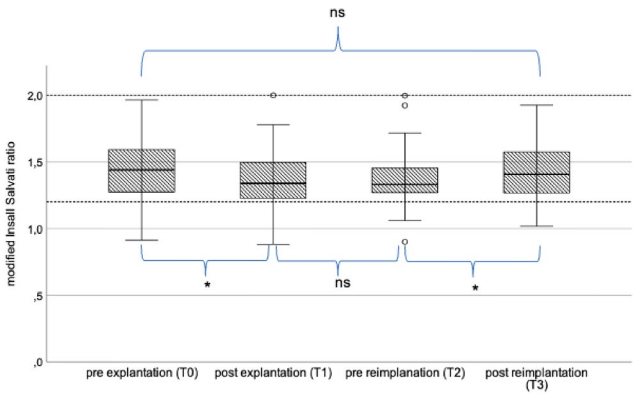

Fig. 4 Modified insall salvati ratios (mISR) at timepoints T0 to T3 displayed as Boxplots. mISR decreased significantly from T0 to T1, remained stable until T2 and increased significantly from T2 to T3. There was no significant difference observed, when comparing T0 to T3. * = significant; ns = not significant

Table 2 Comparison of patients who exhibited major patellar tendon shortening (≥ 10%) over time. mISR = modified Insall-Salvati ratio

	T1	T2	T3
% of all patients	29.2	27.7	9.2
mISR	1.37 ±0.19 [0.9-2.0]	1.43 ±0.21 [1.02–1.93]	1.36 ±0.20 [0.88-2.00]

Subgroup analysis for patients with major shortening

We identified 6 out of 65 patients experiencing patellar tendon shortening of more than 10% between T0 and T3. Overall, 27 patients (42%) showed patellar tendon shortening at any follow-up point. Between T0 and T1, 19 patients (29%) had patellar tendon shortening of more than 10%, and between T0 and T2, 18 patients (28%) had patellar tendon shortening of more than 10%. However, by the third stage, only 6 out of 65 patients (9%) exhibited patellar tendon shortening of more than 10% (Table 2).

Discussion

In this study we evaluated the changes in patellar tendon length during septic two-stage revision TKA using articulating spacers. We found that rTKA using articulating spacers does not lead to patellar tendon shortening in most of the cases in this study cohort. In contrast to the findings of Kirschbaum et al., who reported significant patellar tendon shortening in 33% of cases between the stages with static spacers [15], our cohort displayed a notably lower incidence, with only 9% exhibiting patellar tendon shortening of 10% or more at T3. Moreover, on average, there was no significant alteration in patellar tendon length observed within our cohort.

Notably, in the context of primary TKA, studies have reported a range of 3–6% for patellar tendon shortening exceeding 10% [18, 19]. We found our results to be rather comparable to the results of these two studies, opposing patellar tendon length changes in rTKA using static spacers. As stated in the literature, this similarity might be attributed to the possibility of excessive fat pad resection during rTKA procedures [20–22].

As indicated in the literature, soft tissue impairment and heat damage has been suggested as a potential factor contributing to patellar tendon shortening [15]. Notably, in most cases in this cohort, the mISR tends to increase again after the second stage. This suggests that the adverse effects of the infection may be responsible for these changes. Another potential explanation is that the infection could impact the function of the quadriceps muscle. Additionally, the surgery itself might reduce the pull force of the patellar tendon. Lastly, the choice of optimal spacer thickness could also play a role, as improper thickness may impair ligament tension, especially within the extensor mechanism, by creating a lever arm that is too long in relation to the provisionally restored joint line. Nevertheless, these explanations remain speculative.

Pathogens and comorbidities were not recorded for this study. However, a previous study showed a weak correlation between pathogen and patella tendon shortening and no differences between the groups regarding comorbidities [15].

This study should be interpreted considering its limitations. First, this is a single institution retrospective study that lacks a comparator group, which limits the generalizability of the findings. Second, the study did not include a detailed analysis of pathogenes, which could provide additional insights into the benefits and drawbacks of using articulating spacers in specific patient groups. Third, the selection of patients for articulating versus static spacers may have been influenced by surgeon preference or specific clinical indications, such as severe boneloss or ligament instability, introducing a potential selection bias. Fourth, while the literature has shown comparable reinfection rates and promising clinical outcomes with the use of articulating spacers compared to static spacers [10, 23], these aspects were not analyzed in the present study. Finally, while the sample size was sufficient to identify significant trends, larger studies are needed to confirm these findings and provide more robust conclusions.

Conclusions

Septic two-stage revision TKA using an articulating spacer does not lead to patellar tendon shortening in the majority of cases. These results suggest that the range of motion following reimplantation may be more favorable with the use of articulating spacers compared to static spacers.

References

1. Izakovicova P, Borens O, Trampuz A (2019) Periprosthetic joint infection: current concepts and outlook. EFORT Open Rev 4(7):482–494
2. Ong KL, Kurtz SM, Lau E, Bozic KJ, Berry DJ, Parvizi J (2009) Prosthetic joint infection risk after total hip arthroplasty in the Medicare population. J Arthroplasty 24(6 Suppl):105–109
3. Lazic I, Scheele C, Pohlig F, von Eisenhart-Rothe R, Suren C (2021) Treatment options in PJI - is two-stage still gold standard? J Orthop 23:180–184
4. Gehrke T, Alijanipour P, Parvizi J (2015) The management of an infected total knee arthroplasty. Bone Joint J 97–B(10 Suppl A):20–29
5. Insall JN, Thompson FM, Brause BD (1983) Two-stage reimplantation for the salvage of infected total knee arthroplasty. J Bone Joint Surg Am 65(8):1087–1098
6. Goldstein WM, Kopplin M, Wall R, Berland K (2001) Temporary articulating methylmethacrylate antibiotic spacer (TAMMAS). A new method of intraoperative manufacturing of a custom articulating spacer. J Bone Joint Surg Am 2(2 Pt):83–A
7. Shahpari O, Mousavian A, Elahpour N, Malahias MA, Ebrahimzadeh MH, Moradi A (2020) The Use of Antibiotic Impregnated Cement spacers in the treatment of infected total joint replacement: challenges and achievements. Arch Bone Jt Surg 8(1):11–20
8. Hofmann AA, Kane KR, Tkach TK, Plaster RL, Camargo MP (1995) Treatment of infected total knee arthroplasty using an articulating spacer. Clin Orthop Relat Res (321):45–54
9. Craig A, King SW, van Duren BH, Veysi VT, Jain S, Palan J (2022) Articular spacers in two-stage revision arthroplasty for prosthetic joint infection of the hip and the knee. EFORT Open Rev 7(2):137–152
10. Sina JP, Sabah SA, Schrednitzki D, Price AJ, Hamilton TW, Alvand A (2023) Indications and techniques for non-articulating spacers in massive bone loss following prosthetic knee joint infection: a scoping review Archives of Orthopaedic and Trauma Surgery 143(9):5793–5805. https://doi.org/10.1007/s00402-023-04893-z
11. Voleti PB, Baldwin KD, Lee GC (2013) Use of static or articulating spacers for infection following total knee arthroplasty: a systematic literature review. J Bone Joint Surg Am 95(17):1594–1599
12. Lu J, Han J, Zhang C, Yang Y, Yao Z (2017) Infection after total knee arthroplasty and its gold standard surgical treatment: spacers used in two-stage revision arthroplasty. Intractable Rare Dis Res 6(4):256–261
13. Pivec R, Naziri Q, Issa K, Banerjee S, Mont MA (2014) Systematic review comparing static and articulating spacers used for revision of infected total knee arthroplasty. J Arthroplasty 29(3):553–557e551
14. Park SJ, Song EK, Seon JK, Yoon TR, Park GH (2010) Comparison of static and mobile antibiotic-impregnated cement spacers for the treatment of infected total knee arthroplasty. Int Orthop 34(8):1181–1186
15. Kirschbaum S, Weynandt C, Fuchs M, Perka C, Gwinner C (2022) Major shortening of the patellar Tendon during Septic two-stage knee arthroplasty revision using static spacers. J Arthroplasty 37(9):1851–1857
16. Grelsamer RP, Meadows S The modified Insall-Salvati ratio for assessment of patellar height. Clin Orthop Relat Res 1992(282):170–176
17. Grelsamer RP (2002) Patella baja after total knee arthroplasty: is it really patella baja? J Arthroplasty 17(1):66–69
18. 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
19. Chougule SS, Stefanakis G, Stefan SC, Rudra S, Tselentakis G (2015) Effects of fat pad excision on length of the patellar tendon after total knee replacement. J Orthop 12(4):197–204
20. Lemon M, Packham I, Narang K, Craig DM (2007) Patellar tendon length after knee arthroplasty with and without preservation of the infrapatellar fat pad. J Arthroplasty 22(4):574–580
21. Ye C, Zhang W, Wu W, Xu M, Nonso NS, He R (2016) Influence of the Infrapatellar Fat Pad Resection during total knee arthroplasty: a systematic review and Meta-analysis. PLoS ONE 11(10):e0163515
22. Gwyn R, Kotwal RS, Holt MD, Davies AP (2016) Complete excision of the infrapatellar fat pad is associated with patellar tendon shortening after primary total knee arthroplasty. Eur J Orthop Surg Traumatol 26(5):545–549
23. Mazzucchelli L, Rosso F, Marmotti A, Bonasia DE, Bruzzone M, Rossi R (2015) The use of spacers (static and mobile) in infection knee arthroplasty. Curr Rev Musculoskelet Med 8(4):373–382