Original Article

Comparison of outcomes between static spacers versus articulating spacers in the setting of revision periprosthetic knee infections: a systematic review

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Background: Two-stage exchange arthroplasty is the standard of care treatment for periprosthetic joint infection (PJI) of knee in the United States. This procedure involves implantation of antibiotic-loaded spacer in order to eradicate the infection prior to reimplantation of the prosthesis. While traditionally static spacer was used in interim period between explantation and reimplantation, articulating spacer has become the spacer of choice recently. The purpose of this review is to describe differences in surgical techniques, and clinical outcomes (complications, reinfections) between static and articulating spacers.

Methods: A literature search was performed on PubMed focusing on two-stage revision for infected total knee arthroplasty (TKA) using the search string: [Knee AND (arthroplasty OR replacement) AND (revision OR infection) AND (spacer OR spacers) AND (static or dynamic or articulating or articulated) NOT hip] AND "last 10 years" [PDat] AND Humans [Mesh] AND English [lang].

Results: Initial search yielded 72 results and nine studies with sufficient data were finally included in our systematic review. The total number of knee procedures were 1,977. Static and articulating spacer groups had 871 and 1,106 knees, respectively. The mean time till reimplantation was significantly more in case of articulating (4.5 months) versus static spacers (2.8 months, P<0.001). The mean range of motion (ROM) after surgery was also significantly higher in articulating (101.9°) as compared to static group (93.3°, P<0.001). The mean reinfection and complication rate were not significantly different between articulating and static spacer groups [reinfection: 9.3% *vs.* 14.7%, P=0.190; complication: 7.2% *vs.* 10.6%, P=0.446].

Conclusions: In the setting of two-stage exchange knee arthroplasty, articulating spacers result in better postoperative ROM, but comparable complication and reinfection rates. However, selection bias in the evaluated studies must be considered when comparing outcomes between types of knee spacers. There remain special circumstances of limited soft tissue coverage, ligamentous instability or poor bone stock where static spacer should be considered.

Keywords: Spacer; static spacer; articulating spacer; periprosthetic joint infection (PJI); total knee arthroplasty (TKA); two-stage revision

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Introduction

One of the most serious complications after total knee arthroplasty (TKA) is periprosthetic joint infection (PJI). Despite tremendous advances in the prevention, diagnosis, and treatment of PJI, it remains the most commonly reported cause of early failure in TKA, resulting in the need for subsequent revision (1). The Musculoskeletal Infection Society (MSIS) developed diagnostic criteria in 2011, later modified by the International Consensus Meeting (ICM) in 2013 to standardize and facilitate the diagnostic process (2). Infected total knee arthroplasties can have devastating sequelae such as decreased function, long term stiffness, and increased mortality (1-3). The standard of care for treatment of PJIs is a two-stage revision with implantation of antibiotic loaded cement in order to eradicate the infection prior to reimplantation of the prosthesis (1,4). Traditional static spacers were blocks of antibiotic impregnated cement inserted within the joint space that allowed maintenance of the length and stability of the extremity as well as prevented contraction of the surrounding soft tissues (5-7). Complications such as decreased range of motion (ROM) as well as increased bone loss were associated with this method (6-8). Alternatively, articulating spacers can be used that also contain antibiotic loaded cement along with articulating components or a polyethylene surface that allow ROM during the interim (5,9,10). These articulating spacers can be either fashioned intraoperatively or are commercially available as prefabricated components. A technique using knee implants such as femoral components articulating on all-polyethylene tibias have been used as articulating spacers (11). In recent years, articulating spacers have been more commonly used, although some authors warn against their use due to higher complications rates when compared to static spacers (12,13). Recent studies regarding articulating spacers have reported good clinical outcomes and low rates of reinfection (14-16). The purpose of this paper is to review recent literature comparing the indications, and clinical outcomes achieved with static or articulating spacer types, including ROM attained postoperatively, and reinfection and complication rates.

We present the following article in accordance with the PRISMA reporting checklist (available at http://dx.doi.org/10.21037/aoj-20-80).

Methods

A literature search was performed on PubMed for articles focusing on two-stage knee revision for infected TKA using the following search string on 2/22/2020: [Knee AND (arthroplasty OR replacement) AND (revision OR infection) AND (spacer OR spacers) AND (static or dynamic or articulating or articulated) NOT hip] AND "last 10 years" [PDat] AND Humans[Mesh] AND English [lang]. The initial search yielded 105 results. After screening the title and abstract, 29 records were selected for full-text review. The inclusion criteria for the studies was as follows: studies with use of antibiotic spacers for two-stage revision for infected TKA, minimum of 10 patients, and minimum of 2-year follow-up. Review articles and those with insufficient data were excluded (*Figure 1*). Thus, nine full text articles were finally included in our systematic review (17-25). Of the included nine studies, eight studies addressed articulating spacers. Four investigations focused on static spacers. Three studies compared articulating versus static spacers. However, five studies addressed articulating spacers without any control group.

The data collected from the papers meeting our inclusion criteria were as follows: the number of patients and knees in each study, duration of spacer (time till reimplantation), follow-up time, postoperative ROM, rate of reinfections and rate of complications.

To compare the key outcomes of interest: postoperative ROM, reinfection rates, complication rates between the two types of spacers. Statistical analysis was done with $P<0.05$ indicating a significant difference. Descriptive analyses were performed to compute appropriate descriptive metrics for continuous variables (ROM) and for categorical variables (reinfection rate, complication rate) from the included studies. Postoperative ROM, reinfection rates, and complication rates were compared between static and articulating spacer cohorts. Statistical analyses were conducted using Meta-Analyst software (Providence, RI, USA) developed with funding from the National Center for Research Resources (NCRR) and the Agency for Healthcare Research and Quality (AHRQ).

Results

The total number of patients included in this systematic review were 1,938; static and articulating spacer groups had 850 and 1,088 patients, respectively. The total number of knees were 1,977 (17-25). Static and articulating spacer groups had 871 and 1,106 operated knees, respectively. The mean follow-up for static spacer group was 45.6 (mean range, 40 to 58) months, and 57.2 (mean range, 24 to

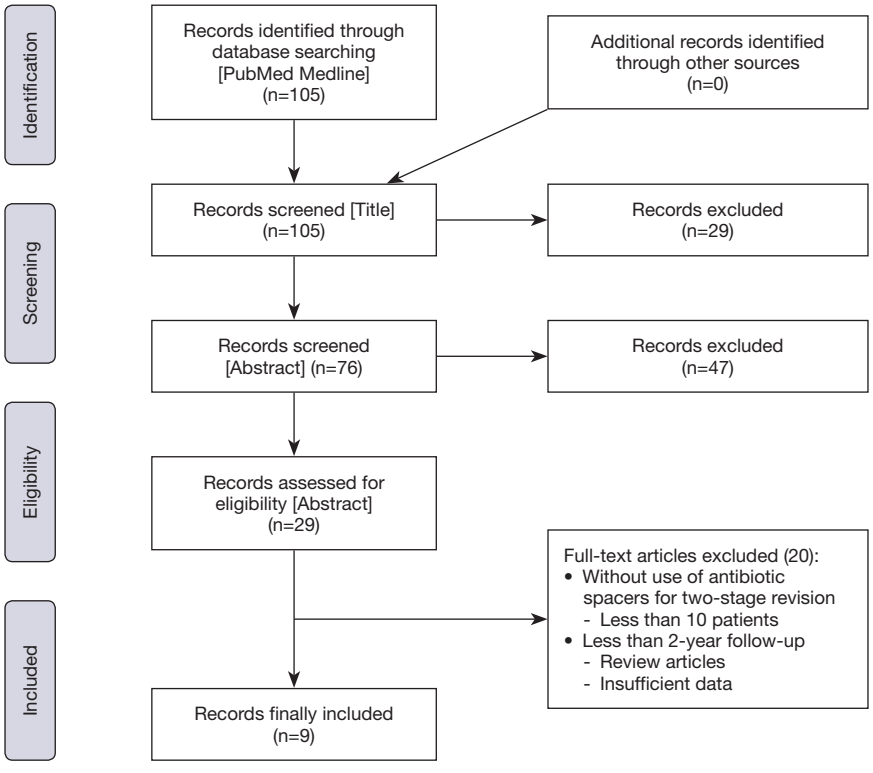

Figure 1 Flowchart for the selection of studies for systematic review.

Table 1 Outcomes of static spacers in two-stage knee revision

Studies	N	Number of knees	Mean follow-up (months)	Re-infection rate (%)	Average flexion (°)
Chiang, 2011	22	22	40	9.50	85
Choi, 2012	33	33	58	33.30	97
Lichstein, 2016	107	109	44.4	6	100
Pivec, 2014	688	707	40	9.70	92
Total	850	871			
Minimum			40	6.00	85
Maximum			58	33.30	100

Descriptive statistics of recent studies focusing on clinical outcomes after implantation of static spacer in two-stage revision knee arthroplasty.

144) months for the articulating spacer group. The descriptive data on static and articulating spacers has been presented in *Table 1* and *Table 2*.

Average time till reimplantation

The final mean time to reimplantation were 2.85 (range, 2.6 to 3.1) months for static spacers 57.2 (mean range, 24 to 144) months and 4.55 (range, 2.6 to 9.1) months in articulating spacer group. The difference in time till reimplantation was found to be statistically significant (P<0.001).

Postoperative ROM

The final mean range-of-motion achieved after surgery was

Table 2 Outcomes of articulating spacers in two-stage knee revision

Studies	N	Number of knees	Mean follow-up (months)	Re-infection rate (%)	Average flexion (°)
Chiang, 2011	23	23	41	4.50	113
Choi, 2012	14	14	58	28.60	100
Chen, 2016	10	10	32.4	20	95
Lee, 2015	20	20	28.4	5	113
Lu, 2018	11	11	24	0	93
Vasso, 2016	42	46	144	9	115
Vecchini, 2016	19	20	74.1	0	79
Pivec, 2014	949	962	56	7.90	100
Total	1,088	1,106			
Minimum			24	0	79
Maximum			144	28.6	115

Descriptive statistics of recent studies focusing on clinical outcomes after implantation of articulating spacer in two-stage exchange knee arthroplasty.

93.3° (range, 88.3° to 98.3°) in the static spacer and 101.9° (range, 94.7° to 109.0°) in the articulating spacer group. There was a significant difference in ROM between the two groups (P<0.001).

Reinfection and complication rate

The mean percentage of reinfections was found to be 14.7% (range, 6% to 33.3%) for static spacers and 9.3% (range, 0% to 28.6%) for articulating spacers. The difference between reinfection rates in the articulating and static spacer groups was not statistically significant (P=0.190). The mean rate of complications seen for static spacer was 10.6%, and 7.2% in the articulating spacer group. There was no significant difference in the mean complication rate between the static and articulating spacer group (P=0.446). Out of all the complications, delayed wound healing and deep venous thrombosis were the most common ones.

Discussion

While there are many investigations in the literature comparing static and articulating spacers (17-25), the objective of this paper was to review the recent evidence on this subject. The results from this investigation show that the patients who had articulating spacers for two-stage knee revision had significant higher postoperative ROM compared to static spacers. Furthermore, articulating spacers demonstrated a trend towards lower reinfection, and complication rate, but differences did not reach a statistical significance.

Our study is associated with several limitations. None of the included studies had randomized controlled trial design and all were retrospective in nature. When conducting a systematic review, there is always a risk of bias within and across the studies, which could have impacted the results in this study. In our analysis, the average time till reimplantation was significantly different between articulating and static spacers. This might have introduced bias in the evaluated outcomes. The lack of information on the selection criteria for either of these spacers in the majority of the reviewed studies did not allow us to run subgroup analysis based on the complexity of cases. Selection bias in choosing a particular spacer for individual patients needs to be acknowledged. In other words, the results of this paper should be looked in light of preference of static spacer in cases with severe bone loss, poor soft tissue coverage, or more resistant organisms. Subgroup analysis of static spacer cases (traditional block-type and newer endoskeleton-type spacer) was not possible in the present investigation. However, significantly worse bone loss with newer spacers might have affected postoperative outcomes in the static spacer cohort (26). Another important point to notice is the ongoing change

in treatment protocols overtime in the included studies. In short, the heterogeneity of the included studies in this review needs to be appreciated. Lastly, since postoperative knee outcome scores (knee society score, HSS score) were not uniformly collected in the reviewed studies, these were not part of our comparative analysis.

In the past, articulating spacers have been demonstrated higher ROM and similar reinfection and complication rates when compared to static spacers (17-25). Our study confirms these prior results. While this investigation demonstrates that articulating spacers offer better ROM, it is important to consider clinical situations which can influence the type of spacer that is used. These scenarios include ligamentous instability, extensive bone loss, or compromised soft tissue coverage. Static spacers, especially newer endoskeleton-type, would likely be a better option offering a stable extremity, reduced tension to the overlying soft tissues, as well as decreased rate of further bone loss (27). Nevertheless, in case of normal bone and soft tissue coverage, an articulating spacer may be the optimal spacer as this provides the patient with a more functional extremity during the interim as well as possible better long-term outcomes.

Conclusions

Overall, articulating spacers are associated with significantly higher postoperative ROM, but comparable reinfection and complication rates when compared to static spacers. These results are based on systematic review of retrospective studies. From a clinical standpoint, the authors recommend the use of articulating spacers unless facing situations of ligamentous instability, severe bone loss, or inadequate soft tissue coverage in which static spacer should be considered. There is dire need of high-quality studies (randomized, prospective) comparing the use of these two types of spacers. In addition, future studies should investigate the differences in clinical outcomes between traditional block-like static spacers and endoskeleton static spacers and also compare them to articulating spacers.

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Footnote

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