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Original Research

Robotic-Assisted Total Knee Arthroplasty Has Similar Rates of Prosthetic Noise Generation as Conventional Total Knee Arthroplasty

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ABSTRACT

Background: Noise has been reported to occur with relatively high frequency after conventional total knee arthroplasty (C-TKA), and this may impact the incidence of patient satisfaction and function. The purpose of this study was to compare the rate of patient-reported prosthetic noise generation after robotically-assisted TKA (RA-TKA) and C-TKA.

Methods: A retrospective study was conducted of unilateral primary RA-TKAs and C-TKAs performed between 2018 and 2021. Patients completed a survey consisting of 4 Likert scale questions related to prosthetic noise generation and Knee Injury and Osteoarthritis Score Joint Replacement and Forgotten Joint Score were assessed prospectively preoperatively and at a minimum of 1-year of clinical follow-up. Statistical analysis was done utilizing T-tests and chi-square tests, with statistical significance defined as a P-value $< .05$.

Results: One hundred sixty-two RA-TKAs and 320 C-TKAs with similar baseline characteristics and functions were included. There were no significant differences in hearing or feeling grinding, popping, clicking, or clunking (40.7% vs 38.1%; $P = .647$) between groups. Most RA-TKAs and C-TKAs were not dissatisfied regarding noise generation (70.4% vs 73.1%; $P = .596$). In both cohorts, patients who reported noise generation had lower average Forgotten Joint Scores (45.5 vs 66.1; $P < .001$) and lower post-operative Knee Injury and Osteoarthritis Score Joint Replacement scores (72.0 vs 81.4; $P < .001$) than those who did not experience noise generation.

Conclusions: While RA-TKA may facilitate soft tissue balancing, there were no differences in prosthetic noise generation between RA-TKA and C-TKA. However, those who experience implant-generated noise have lower functional outcome scores.

Introduction

Despite improvements in total knee arthroplasty (TKA) surgical techniques, implant design, and perioperative protocols, there still remains a population of about 20%-30% who are dissatisfied with the results after TKA [1,2]. Patients frequently report implant-related noise generation such as clicking, snapping, cracking, and popping after undergoing conventional total knee arthroplasty (C-TKA) [3,4]. While historically, implant-related noise was frequently attributed to patellar clunk syndrome in posteriorly stabilized knees, recent advancements in implant design have limited the occurrence of this condition [5,6], thus leaving other primary sources of noise in TKA [4]. Despite a variety of modifications in implant design and surgical technique, patients still report some degree of audible implant-related noise or noise-related symptoms following TKA surgery. Sharkey and Miller reported that as many as 69% of patients had noise in their knees, three-quarters of whom did not anticipate these symptoms prior to TKA surgery [4]. On the other hand, a retrospective study by Nam et al. found that 27% of patients experienced noise from their TKA [7].

Use of robotic-assisted total knee arthroplasty (RA-TKA) has become increasingly common [8], with the aim of improving functional outcomes and durability after TKA as well as reducing dissatisfaction. However, when considering potential alternative benefits of RA-TKA [9-12], it is unknown whether improvements in

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component positioning and soft tissue balancing achieved in RA-TKA may impact the generation of implant-related noise. To our knowledge, no studies have examined whether patients who undergo RA-TKA experience less implant-related noise as compared to patients undergoing C-TKA.

The purpose of this study is to determine if there is a significant difference in the amount of audible noise or symptoms such as grinding, popping, or clicking generated by the implant in RA-TKA compared to C-TKA. Additionally, the secondary purposes are to compare the Forgotten Joint Scores (FJSs) between patients who reported noise generation and those who did not, and to compare FJSs between patients who received different polyethylene inserts and patellar resurfacing. We hypothesize that implant-related noise and symptom generation in RA-TKA will be less than those observed in C-TKA.

Material and methods

Study design

This study was a single-institution retrospective survey assessing patient-reported noise and residual symptoms (such as popping, grinding, clunking, clicking, and crackling), as well as functional outcomes, at a minimum of 1 year following primary TKA. All of the TKAs utilized the Persona TKA (Zimmer Biomet, Warsaw, IN) with and without the robotic assistance of the ROSA Knee robot (Zimmer Biomet, Warsaw, IN). The C-TKAs were performed using a mechanical alignment technique, and the RA-TKAs were performed utilizing a restricted kinematic alignment algorithm; irrespective of the approach, the goal was to achieve a balanced knee. The surgeries were performed by 4 fellowship-trained arthroplasty surgeons from 2018 to 2021. Patients who underwent C-TKA were compared to patients who underwent RA-TKA.

The survey was sent to eligible patients via email through the Health Insurance Portability and Accountability Act-compliant software (REDCap; Vanderbilt University, Nashville, TN). Eligible participants received the survey in May 2022 and again in September 2022, with up to 6 reminder emails if they did not complete the survey.

Inclusion and exclusion criteria

Patients were eligible for participation in this study if they underwent unilateral primary TKA with or without robotic assistance for osteoarthritis, had at least 1 year of clinical follow-up, had a completed functional outcome score preoperatively, and had a Persona TKA implant. Patients were excluded from this study if their TKA was performed for inflammatory or posttraumatic arthritis or if their index operation was a simultaneous bilateral TKA, revision TKA, conversion TKA, or partial knee arthroplasty. Patients were also excluded if they had no email in our institutional database or no completed functional outcomes score preoperatively.

Data collection

Demographic information such as age, sex, body mass index, nonage adjusted Charlson comorbidity index, primary TKA date, and laterality of TKA were obtained from our institutional arthroplasty database, which collects data prospectively. Additionally, preoperative Knee Injury and Osteoarthritis Score Joint Replacement (KOOS-JR) scores were obtained from our prospectively collected institutional database (See Table 1). Implant types including polyethylene insert type and whether or not the patella was resurfaced were obtained from the retrospective review of the operative records (see Table 1). The electronic survey that was sent to patients consisted of 4 Likert scale questions related to prosthetic noise generation and satisfaction, the FJS, and the KOOS-JR. Primary outcomes included patient-reported noise and noise-related symptoms in the 30 days prior to being surveyed. Secondary outcomes include the FJS to assess prosthetic joint awareness following surgery as well as the KOOS-JR score for functional outcome assessment.

Table 1
Patient characteristics.

	Total patients (N = 482)	RA-TKA (N = 162)	C-TKA (N = 320)	*P*-value
Age (years)	65.5 (8.83)	67.0 (7.99)	64.7 (9.15)	**.005**
Sex				.148
Men	199 (41.3%)	59 (36.4%)	140 (43.8%)	
Women	283 (58.7%)	103 (63.6%)	180 (56.2%)	
BMI (kg/m^2)	30.2 (5.0)	30.4 (5.1)	30.1 (5.0)	.513
CCI	0.5 (0.86)	0.5 (0.85)	0.6 (0.87)	.570
KOOS-JR	48.8 (13.3)	46.6 (14.5)	49.9 (12.6)	**.017**
Laterality				1.000
Right	248 (51.5%)	83 (51.2%)	165 (51.6%)	
Left	234 (48.5%)	79 (48.8%)	155 (48.4%)	
Implant style				**<.001**
CR	195 (40.5%)	13 (8.0%)	182 (56.9%)	
PS	115 (23.9%)	92 (56.8%)	23 (7.2%)	
UC	130 (27.0%)	21 (13.0%)	109 (34.1%)	
MC	36 (7.5%)	34 (21.0%)	2 (0.6%)	
CPS	6 (1.2%)	2 (1.2%)	4 (1.3%)	
Patella resurfacing				.847
Yes	159 (33.0%)	52 (32.1%)	107 (33.4%)	
No	323 (67.0%)	110 (67.9%)	213 (66.6%)	

Values given as mean (SD) or number (%).
Bold values indicate statistical significance.
BMI, body mass index; CCI, Charlson comorbidity index; CR, cruciate retaining; PS, posterior stabilized; UC, ultra-congruent; MC, medial-congruent; CPS, constrained posterior-stabilized.

Patient characteristics

The survey was sent to 940 patients who underwent either RA-TKA or C-TKA from 2018 to 2021, among whom 482 patients responded, giving a response rate of 51.3%. The participants consisted of 320 C-TKA and 162 RA-TKA patients. There were no significant differences in body mass index or Charlson comorbidity index between the groups (see Table 1). Although a greater portion of survey respondents were women in both groups, patients in the RA-TKA group were older on average (67.0 vs 64.7; $P = .005$), and the mean preoperative KOOS-JR was lower in the RA-TKA group (46.6 vs 49.9; $P = .017$), indicating a slightly higher degree of baseline disability in the RA-TKA group. The distribution of polyethylene inserts used in each group, as well as limb laterality and incidence of patellar resurfacing are included (see Table 1).

Statistical analysis

With an alpha of 0.05 and power of 80%, 276 patients were needed to be enrolled in this study, with at least 138 patients in both the C-TKA and RA-TKA groups. Descriptive analyses were performed for the full cohort. A multivariate analysis was performed to account for demographic variables, differences in implant types (cruciate-retaining, ultra-congruent, medial-congruent, posterior-stabilized, constrained posterior-stabilized), and patellar resurfacing. A chi-square analysis and Fisher's exact test were used to compare categorical data and to report the frequency of noise and residual symptoms in patients who underwent

Table 2
Data collected from survey.

	Total patients (N = 482)	RA-TKA (N = 162)	cTKA (N = 320)	*P*-value
How often have you heard grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?				.647
Never/rarely	294 (61.0%)	96 (59.3%)	198 (61.9%)	
Sometimes/often/extremely often	188 (39.0%)	66 (40.7%)	122 (38.1%)	
How often have you felt grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?				.500
Never/rarely	309 (64.1%)	100 (61.7%)	209 (65.3%)	
Sometimes/often/extremely often	173 (35.9%)	62 (38.3%)	111 (34.7%)	
If you heard or felt grinding, popping, clicking, or clunking from your knee replacement within the last 30 days, does the noise generation or sensation cause discomfort?				.967
Never/rarely	207 (70.9%)	73 (73%)	134 (69.8%)	
Sometimes/often/extremely often	85 (29.1%)	27 (27%)	58 (30.2%)	
How satisfied are you with the amount of noise that your knee replacement makes?				.596
Very unsatisfied/unsatisfied	134 (27.8%)	48 (29.6%)	86 (26.9%)	
Neutral/satisfied/very satisfied	348 (72.2%)	114 (70.4%)	234 (73.1%)	
Forgotten Joint Score	58.1 (30.2)	54.7 (30.3)	59.8 (30.1)	.081
Postoperative KOOS-JR	77.7 (18.8)	75.7 (18.8)	78.7 (18.8)	.105
DELTA KOOS-JR	28.9 (20.5)	29.2 (21.2)	28.7 (20.2)	.808

Values given as number (%) or mean (SD).

RA-TKA compared to C-TKA. *P*-values less than .05 were deemed statistically significant. All statistical analyses were performed using R Studio (Version 3.6.3, Vienna, Austria).

Results

The RA-TKAs and C-TKAs groups reported similar rates of *hearing* grinding, popping, clicking, or clunking from their implant within the last 30 days of receiving the survey (40.7% vs 38.1%; $P = .647$) (see Table 2). Similarly, there were no statistically significant differences in the 2 groups that reported feeling grinding, popping, clicking, or clunking in the knees within 30 days of the survey (38.3% vs 34.7%; $P = .500$). Of those who reported either hearing or feeling these sensations, 73% of RA-TKA patients and 69.8% of C-TKA patients ($P = .967$) reported that the noise generation or sensation does not cause discomfort. Most RA-TKAs and C-TKAs were not dissatisfied regarding noise generation from their prosthetic knee replacement (70.4% vs 73.1%; $P = .596$).

The RA-TKAs and C-TKAs had similar average FJSs (54.7 vs 59.8; $P = .081$), with no significant differences between those who reported hearing noises and those who did not in each group. Likewise, there were no significant differences in the postoperative KOOS-JR score (75.7 vs 78.7; $P = .105$) between groups. However, patients who reported hearing noise in both groups had lower average FJSs than those who did not (45.5 vs 66.1; $P < .001$) and lower average postoperative KOOS-JR scores (72.0 vs 81.4; $P < .001$) (see Table 3). Likewise, those who reported feeling symptoms related to noise generation had lower average FJSs (43.2 vs 66.4; $P < .001$) and lower average postoperative KOOS-JR scores (70.4 vs 81.8; $P < .001$) than those who did not report these sensations.

There were no significant differences between the implant styles and noise generation (see Table 4). While those with posterior-stabilized, medial-congruent, and constrained posterior-stabilized implants had statistically significant lower average FJSs, indicating higher levels of awareness of the knee joint, the study was not adequately powered to determine differences between implant styles. There were no significant differences in noise generation, FJS, or KOOS-JR scores based on whether patellae were resurfaced or not (See Table 5).

The results of the multivariate analysis found that age was the only significant factor regarding patients who reported hearing or feeling noise from their prosthesis (Table 6). However, implant types did not significantly impact reports of noise or patient satisfaction.

Discussion

Prosthetic noise generation, and noise-related symptoms such as grinding, popping, or clicking, and implant awareness are similar between RA-TKA and C-TKA, contrary to our hypothesis that their incidence would be less in RA-TKA compared to C-TKA. In the current study, 39.0% of all TKA patients heard noise, which is slightly higher than that reported by Nam et al. (29.0%) [7] and Parvizi et al. (33.0%) [13], but lower than that reported by Sharkey and Miller [4]. 29% of studied patients have discomfort associated with the symptoms of noise, and 28% of patients are dissatisfied

Table 3
Comparison of total patients who heard/felt noise to functional outcomes.

How often have you heard grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?	Never/rarely (N = 294)	Sometimes/often/extremely often (N = 188)	*P*-value
Forgotten Joint Score	66.1 (28.7)	45.5 (28.3)	**<.001**
Postoperative KOOS-JR	81.4 (15.9)	72.0 (21.5)	**<.001**
How often have you felt grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?	Never/rarely (N = 309)	Sometimes/often/extremely often (N = 173)	*P*-value
Forgotten Joint Score	66.4 (28.7)	43.2 (27.2)	**<.001**
Postoperative KOOS-JR	81.8 (15.8)	70.4 (21.5)	**<.001**

Values given as mean (SD).
Bold values indicate statistical significance.

Table 4
Comparison of noise generation based on implant styles.

	CR (N = 195)	PS (N = 115)	UC (N = 130)	MC (N = 36)	CPS (N = 6)	*P*-value
How often have you heard grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?						.436
Never/rarely	126 (64.6%)	63 (54.8%)	78 (60.0%)	24 (66.7%)	3 (50%)	
Sometimes/often/extremely often	69 (35.4%)	52 (45.2%)	52 (40.0%)	12 (33.3%)	3 (50%)	
How often have you felt grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?						.773
Never/rarely	131 (67.2%)	71 (61.7%)	82 (63.1%)	22 (61.1%)	3 (50%)	
Sometimes/often/extremely often	64 (32.8%)	44 (38.3%)	48 (36.9%)	14 (38.9%)	3 (50%)	
Forgotten Joint Score	62.2 (29.3)	51.6 (30.3)	60.1 (30.0)	52.0 (31.8)	43.4 (34.2)	**.014**
Postoperative KOOS-JR	79.2 (18.4)	76.0 (19.8)	78.9 (18.9)	72.7 (14.8)	65.0 (25.7)	.092

Values given as number (%) or mean (SD).
Bold values indicate statistical significance.
CR, cruciate retaining; PS, posterior stabilized; UC, ultra-congruent; MC, medial-congruent; CPS, constrained posterior-stabilized.

with the “noise” they feel or hear. This may help explain some of the dissatisfaction from residual symptoms described in the series by Noble et al. [14] and complement the work done by others, which reported a link between greater noise-related symptoms and either dissatisfaction or function limitations [3,4,7].

One of the challenges in TKA is to lower awareness of the replacement. Noise generation is one factor that can cause awareness of a joint replacement. The FJS is a validated way to assess a patient’s level of awareness of their knee replacement throughout a variety of activities [15,16]. In this study, we looked at the differences in the FJSs between the RA-TKA and C-TKA groups and found no statistically significant differences. However, the presence of prosthetic noise and noise-related symptoms in both groups had a correlation with lower average FJSs and lower KOOS-JR scores, findings that reached statistical significance and differed from another study that reported that patient-reported noise has limited effect on joint awareness and clinical outcomes [17].

While innovation in implant designs have improved reports of noise-related from patellar clunk [5,6], and differences in implant designs can affect the incidence of residual symptoms [18], the present study found no relationship between multiple variables such as polyethylene liner type, level of constraint, and whether the patella was resurfaced and the incidence of implant-generated noise. This differs from a study by Nam et al., which found that posterior-stabilized knee implants and rotating-platform designs have a greater likelihood of noise generation than cruciate-retaining knees [7]. Further, while Pritchett found that noise-related symptoms were more common with particular implant designs and levels of constraint, occurring in 4% of patients with bicruciate retaining implants, 12% of patients with medial pivot prostheses, 31% of patients with posterior cruciate ligament retaining implants, 33% of patients with posterior-stabilized implants, and 42% of patients with mobile bearing knees [3], we were unable to ascribe a higher incidence of noise-related symptoms to any particular implant style or constraint level in our series, irrespective of whether robotic assistance was used. However, the variations in implant styles can affect ligament tension and gap opening through the arc of motion, which may affect the results of this study. While our study found that those with posterior-stabilized, medial-congruent, and constrained posterior-stabilized styles of inserts, across groups, had statistically significant lower average FJSs, indicating higher levels of implant awareness, we were underpowered to draw meaningful conclusions between implant types and the incidence of noise. Conversely, a study by Kim et al. compared bilateral knees in 50 patients, also using the Persona (Zimmer Biomet) implants, and found that ultra-congruent knees had less noise generation than posterior-stabilized knees, but there were no differences in FJS [19].

Finally, our study did not find any differences in noise generation between resurfaced and nonresurfaced patella in either the RA-TKA or C-TKA cohorts. This differs from a meta-analysis by Chen et al., which found a statistically significant difference between resurfaced and nonresurfaced patellae in TKA, with far greater noise generation in patellae that were not resurfaced [20]. The findings of our study do not support that conclusion, although in our cohorts, the principle of selective patellar resurfacing was followed, whereby the patellae were left unresurfaced only if there was no significant lateral patellar facet arthritis. This is different than the meta-analysis [20], which did not account for the severity of patellar arthritis. Additionally, our study did not find statistically significant differences in FJSs or KOOS-JR scores between resurfaced and nonresurfaced patellae, which is similar to prior studies [21,22].

The findings of this study rely on patient-reported awareness of hearing or feeling noise-related symptoms after TKA. Although 39% of the total patient population reported hearing noise and 36% of patients reported feeling symptoms related to noise generation, age and hearing loss may play a role in some patients abilities to self-

Table 5
Comparison of noise generation based on patellae resurfacing.

	Resurfaced patella (N = 159)	Nonresurfaced patella (N = 323)	*P*-value
How often have you heard grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?			.137
Never/rarely	89 (56.0%)	205 (63.5%)	
Sometimes/often/extremely often	70 (44.0%)	118 (36.5%)	
How often have you felt grinding, popping, clicking, or clunking from your knee replacement within the last 30 days?			.371
Never/rarely	97 (61.0%)	212 (65.6%)	
Sometimes/often/extremely often	62 (39.0%)	111 (34.4%)	
Forgotten Joint Score	57.2 (29.9)	58.5 (30.5)	.667
Postoperative KOOS-JR	76.5 (19.5)	78.3 (18.5)	.337

Values given as number (%) or mean (SD).

Table 6
Multivariate logistic regression of noise symptoms.

Variable	Heard noise	Felt noise	Noise satisfaction
Conventional	1.28 (0.68-2.43) 0.446	1.08 (0.67-2.05) 0.822	1.45 (0.74-2.89) 0.284
Age	0.97 (0.95-0.99) **0.046**	0.97 (0.95-0.99) **0.033**	0.97 (0.95-1.00) 0.069
BMI	0.98 (0.94-1.03) 0.456	1.00 (0.95-1.05) 0.959	0.96 (0.91-1.00) 0.067
Sex	0.67 (0.43-1.04) 0.074	0.80 (0.51-1.26) 0.340	0.86 (0.54-1.38) 0.537
CCI	0.87 (0.67-1.13) 0.324	0.79 (0.59-1.03) 0.088	0.76 (0.55-1.01) 0.071
Pre OP KOOS Jr	1.00 (0.98-1.01) 0.611	0.99 (0.97-1.01) 0.265	1.00 (0.98-1.02) 0.951
Poly style			
CR	Reference	Reference	Reference
PS	1.96 (0.95-4.08) 0.070	1.27 (0.61-2.65) 0.524	2.07 (0.96-4.55) 0.065
UC	1.33 (0.75-2.37) 0.334	1.26 (0.70-2.25) 0.442	1.16 (0.62-2.15) 0.647
MC	1.11 (0.41-2.95) 0.828	1.22 (0.46-3.22) 0.682	1.47 (0.51-4.15) 0.467
CPS	4.79 (0.43-107.54) 0.215	1.20 (0.05-14.00) 0.890	1.77 (0.08-20.09) 0.655

Data presented as odds ratio, 95% confidence interval, and *P*-values.
Bolded values indicate statistical significance.
BMI, body mass index; CCI, Charlson comorbidity index; Pre Op KOOS JR, preoperative Knee Injury Osteoarthritis Outcome Score, Joint Replacement; CR, cruciate retaining, PS, posterior stabilized, UC, ultra-congruent; MC, medial congruent; CPS, constrained posterior stabilized.

report for these survey questions of interest. In this study, patients in the RA-TKA group had a statistically significant higher age (67.0 vs 64.7; $P = .005$). Nonetheless, in addition to similar rates of hearing noise in both the RA-TKA and C-TKA groups, the incidence of feeling symptoms, a "noise variant" of sorts, was also comparable between groups. In the future, the use of vibroarthrography [23] may be a useful tool to better quantify knee acoustic emissions and knee prosthesis-generated noise.

Strengths of this study include that this is the first study, to our knowledge, to assess implant-related noise generation between C-TKA and RA-TKA in a study adequately powered for both groups. Additionally, the survey responses pertaining to patient-reported noise generation and satisfaction were able to be compared to functional outcome scores. However, there are limitations to this study worth noting. This is a retrospective study, which may be subject to volunteer bias and nonresponse bias, which could impact the results despite a strong survey response rate of 51.3%. Study participants may have been more inclined to participate if they experienced noise generation or noise-related symptoms. Although it was a strength of this study that a single implant design and single robotic system were used, the results of this study may not be generalizable across a broader range of implants or different robots. Further, this study was not powered to determine differences in noise and noise-related symptoms based on implant styles or levels of constraint. This may be the basis for further studies. Finally, an ongoing study is being performed to determine how quantified measures of soft tissue balance may impact noise generation in RA-TKA.

Conclusions

While image-free RA-TKA may facilitate improved soft tissue balancing and component alignment compared to C-TKA, there were no differences in prosthetic noise generation or noise-related symptoms between image-free RA-TKA and C-TKA in this study. Irrespective of surgical technique, patients who reported hearing noise generation or feeling noise-related symptoms had worse functional outcomes.

Conflicts of interest

G. Klein is a paid consultant and receives royalties and research support from Zimmer Biomet; he receives financial support from Jay Pee Publishers; and he serves as an editorial/governing board member of the American Academy of Orthopaedic Surgeons. A. Seidenstein is a paid consultant and receives royalties from Zimmer Biomet. H. Levine is a speaker and paid consultant for Zimmer Biomet; he serves as an editorial/governing board member of the Journal of Arthroplasty; and he also serves as a Knee Committee member of the American Academy of Orthopaedic Surgeons. J. Lonner is a speaker bureau member and receives royalties from Zimmer Biomet and Smith & Nephew; he is a paid consultant and receives research support from Zimmer Biomet, Smith & Nephew, and Force Therapeutics; he has stock options in Force Therapeutics and Proteonova; he receives royalties from Elseiver, Springer, and Wolters Kluwer Health; and he serves as a board or committee member of the American Association of Hip and Knee Surgeons.

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References

[1] Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KDJ. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57–63. https://doi.org/10.1007/s11999-009-1119-9.
[2] Gunaratne R, Pratt DN, Banda J, Fick DP, Khan RJK, Robertson BW. Patient dissatisfaction following total knee arthroplasty: a systematic review of the literature. J Arthroplasty 2017;32:3854–60. https://doi.org/10.1016/j.arth.2017.07.021.
[3] Pritchett JW. A comparison of the noise generated from different types of knee prostheses. J Knee Surg 2013;26:101–4. https://doi.org/10.1055/s-0032-1319779.
[4] Sharkey PF, Miller AJ. Noise, numbness, and kneeling difficulties after total knee arthroplasty: is the outcome affected? J Arthroplasty 2011;26:1427–31. https://doi.org/10.1016/j.arth.2010.10.009.
[5] Lonner JH, Jasko JG, Bezwada HP, Nazarian DG, Booth RE. Incidence of patellar clunk with a modern posterior-stabilized knee design. Am J Orthop (Belle Mead NJ) 2007;36:550–3.
[6] Ip D, Ko PS, Lee OB, Wu WC, Lam JJ. Natural history and pathogenesis of the patella clunk syndrome. Arch Orthop Trauma Surg 2004;124:597–602. https://doi.org/10.1007/s00402-003-0533-9.
[7] Nam D, Barrack T, Nunley RM, Barrack RL. What is the frequency of noise generation in modern knee arthroplasty and is it associated with residual symptoms? Clin Orthop Relat Res 2017;475:83–90. https://doi.org/10.1007/s11999-016-4701-y.
[8] Sherman WF, Wu VJ. Robotic surgery in total joint arthroplasty: a survey of the AAHKS membership to understand the utilization, motivations, and perceptions of total joint surgeons. J Arthroplasty 2020;35:3474–3481.e2. https://doi.org/10.1016/j.arth.2020.06.072.
[9] Lonner JH, Fillingham YA. Pros and cons: a balanced view of robotics in knee arthroplasty. J Arthroplasty 2018;33:2007–13. https://doi.org/10.1016/j.arth.2018.03.056.
[10] Haffar A, Krueger CA, Goh GS, Lonner JH. Total knee arthroplasty with robotic surgical assistance results in less physician stress and strain than conventional methods. J Arthroplasty 2022;37:S193–200. https://doi.org/10.1016/j.arth.2021.11.021.

[11] Deckey DG, Verhey JT, Rosenow CS, Doan MK, McQuivey KS, Joseph AM, et al. Robotic-assisted total knee arthroplasty allows for trainee involvement and teaching without lengthening operative time. J Arthroplasty 2022;37:S201–6. https://doi.org/10.1016/j.arth.2021.12.030.
[12] Lonner JH, Goh GS. Moving beyond radiographic alignment: applying the Wald Principles in the adoption of robotic total knee arthroplasty. Int Orthop 2023;47:365–73. https://doi.org/10.1007/s00264-022-05411-3.
[13] Parvizi J, Nunley RM, Berend KR, Lombardi AV, Ruh EL, Clohisy JC, et al. High level of residual symptoms in young patients after total knee arthroplasty. Clin Orthop Relat Res 2014;472:133–7. https://doi.org/10.1007/s11999-013-3229-7.
[14] Noble PC, Conditt MA, Cook KF, Mathis KB. The John Insall Award: patient expectations affect satisfaction with total knee arthroplasty. Clin Orthop Relat Res 2006;452:35–43. https://doi.org/10.1097/01.blo.0000238825.63648.1e.
[15] Thomsen MG, Latifi R, Kallemose T, Barfod KW, Husted H, Troelsen A. Good validity and reliability of the forgotten joint score in evaluating the outcome of total knee arthroplasty. Acta Orthop 2016;87:280–5. https://doi.org/10.3109/17453674.2016.1156934.
[16] Eichler D, Beaulieu Y, Barry J, Massé V, Vendittoli P-A. Perception of a natural joint after total knee arthroplasty. J Arthroplasty 2020;35:358–63. https://doi.org/10.1016/j.arth.2019.09.036.
[17] Taniguchi H, Itoh M, Yoshimoto N, Itou J, Kuwashima U, Okazaki K. Noise after total knee arthroplasty has limited effect on joint awareness and patient-reported clinical outcomes: retrospective study. BMC Musculoskelet Disord 2020;21:115. https://doi.org/10.1186/s12891-020-3134-7.
[18] Nunley RM, Nam D, Berend KR, Lombardi AV, Dennis DA, Della Valle CJ, et al. New total knee arthroplasty designs: do young patients notice? Clin Orthop Relat Res 2015;473:101–8. https://doi.org/10.1007/s11999-014-3713-8.
[19] Kim MS, Koh IJ, Kim CK, Choi KY, Jeon JH, In Y. Comparison of joint perception between posterior-stabilized and ultracongruent total knee arthroplasty in the same patient. J Bone Joint Surg Am 2021;103:44–52. https://doi.org/10.2106/JBJS.20.00279.
[20] Chen K, Dai X, Li L, Chen Z, Cui H, Lv S. Patellar resurfacing versus non-resurfacing in total knee arthroplasty: an updated meta-analysis of randomized controlled trials. J Orthop Surg Res 2021;16:83. https://doi.org/10.1186/s13018-020-02185-5.
[21] Ko YI, Yang JH, Choi CH. Comparison of clinical outcomes after total knee arthroplasty with and without patellar resurfacing in the same patients. Clin Orthop Surg 2022;14:361–9. https://doi.org/10.4055/cios20289.
[22] Noh JH, Kim NY, Song KI. Comparison of clinical outcomes between patellar resurfacing and patellar non-resurfacing in cruciate retaining total knee arthroplasty. J Orthop Surg 2022;30:10225536221092224. https://doi.org/10.1177/10225536221092223.
[23] Kalo K, Niederer D, Sus R, Sohrabi K, Groß V, Vogt L. Reliability of vibroarthrography to assess knee joint sounds in motion. Sensors (Basel) 2020;20:E1998. https://doi.org/10.3390/s20071998.