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Original Research

The Impact of Cementing Techniques on Implant Longevity in Relation to Keel Length in Persona and NexGen Knee Arthroplasty: A Comprehensive Study

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ABSTRACT

Background: The aim of this study was to investigate the efficacy of our modified cementing technique in reducing the rate of aseptic tibial loosening focusing on its relationship with keel length.

Methods: Every participant who underwent primary total knee arthroplasty (TKA) between August 2014 and September 2022 with a minimum of 4-year follow-up using 1 of 3 implants were included: Persona + conventional cementing technique; Persona + modified cementing technique; and NexGen LPS-Flex. The modifications applied include better preparation of the bone surfaces and the cancellous bone cavities, pressurizing the cement and interstitial fluid suction at the same time, applying a layer of cement on the surfaces of the tibia and implant, and immobilizing the limb. Kaplan-Meier analyses were performed to estimate survivorship.

Results: A total of 988 of 1039 primary TKAs (95.1%) were included with follow-up of 89.26 ± 7.32 months. Twenty eight (2.83%) TKA required revisions due to aseptic tibial loosening; 3 (1.1%) in the NexGen group, 21 (6.9%) in the conventionally cemented Persona group, and 4 (0.9%) within the modified cemented Persona group. Aseptic loosening occurred at a mean of 69.00 ± 2.65, 34.57 ± 22.90, and 68.50 ± 3.42, respectively. Survivorship for aseptic loosening was 98.9%, 93.1%, and 99.1% at 8 years, respectively. The revision rate for early (during the first 24 months) aseptic loosening was 4.6% in the conventionally cemented Persona group. No early aseptic loosening reported in other 2 groups.

Conclusions: In conclusion, meticulous cementing techniques can reduce the rate of tibial loosening in shorter keel designs.

Introduction

Total knee arthroplasty (TKA) has long been a dependable solution for treating symptomatic knee arthritis, boasting a survival rate of more than 90% after 15 years of follow-up [1,2]. However, the durability of TKA can be compromised by issues like septic or mechanical failures, stemming from various factors, including surgical procedures and implant design [3]. One of the most prominent mechanical failures is aseptic loosening, typically occurring at a mean of 7 years post-TKA, and responsible for a significant portion of revision surgeries [4-6]. To address this, cemented implants emerged as the gold standard, offering stability and longevity [7,8]. In particular, cemented tibial components, with or

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without a stem, have exhibited superior biomechanical results [9,10].

As the demand for primary TKA increased, manufacturers aimed to enhance implant cost-efficiency and long-term performance [11]. Reduced tibial bone damage and improved shear stress tolerance are provided by shorter keels with a cemented stem [12,13]. However, concerns about their ability to withstand torsional and tilting forces, rates of micromotion, and generating wear particles persist [14,15].

In this context, the Persona (Zimmer Biomet) Personalized Knee System emerged in 2012, building upon the NexGen Knee System to create a more anatomically accurate knee implant [16,17]. This novel design aimed to replicate normal knee kinematics, featuring a side-specific tibial component, tighter polyethylene increments, and shorter tibial keels. These innovations promised better postoperative knee stability and the preservation of bone stock during revisions [18].

However, recent investigations have prompted worries regarding an elevated risk of tibial component micromovement, migration, and aseptic loosening due to the contemporary designs of shorter tibial keel [3,14,19-22]. To counteract this, advancements in cementing techniques have improved outcomes in cemented TKA. These techniques involve compression with a cement gun, vacuum mixing, precooling the cement, drilling holes in sclerotic areas, bone drying, high-pressure lavage, and careful cement mixing ratios [23-25].

In early 2014, our institutions transitioned from using the NexGen LPS-Flex tibial baseplate in primary TKAs to adopting the newer Persona (Zimmer Biomet) option. However, this shift was followed by a notable rise in cases in need of preliminary revision due to aseptic loosening, especially affecting the implant's tibial surface. To address this issue, we conducted a thorough literature review and decided to make a significant change: modifying our cementing technique, inspired by the practices employed in total hip arthroplasty.

The primary objective of our study was to assess the impact of our modified cementing technique on reducing the occurrence of aseptic tibial loosening in Persona (Zimmer Biomet) implants compared to those implanted using the conventional cementing method. Additionally, we aimed to compare the rate of aseptic tibial loosening between Persona (Zimmer Biomet) implants with the modified cementation technique, and the previously used NexGen implants, and previously used Persona (Zimmer Biomet) with conventional cementing technique. Our hypothesis was that, despite the observed increase in aseptic tibial loosening in Persona (Zimmer Biomet) tibial components without our modified cementing technique, the rate of revision for loosening would be similar between NexGen tibial components and Persona (Zimmer Biomet) tibial components with our modified cementing approach.

Material and methods

A comparative, retrospective, multicenter cohort with a same surgical team was performed for all primary TKA between August 2014 and September 2022 in our division with at least 4 years of surveillance.

Upon institutional review board approval, a consecutive series of individuals who experienced primary TKA using NexGen between August 2014 and August 2016, and those who were operated with Persona (Zimmer Biomet) between August 2016 and September 2022, were identified from our joint registry databases of the participating hospitals. One of 3 arthroplasty surgeons with fellowship training conducted all surgeries. All patients who underwent primary TKA using 1 of these 3 were considered eligible to include in the study:

- Control group 1: The NexGen LPS-Flex system (Zimmer Biomet, USA) with our conventional cementing technique.
- Control group 2: The Persona Knee System (Zimmer Biomet, USA) with our conventional cementing technique.
- Cementing intervention group: The Persona Knee System with our "modified cementing technique".

All the implants were posterior stabilized and cemented using Hi-Fatigue G Bone cement (Zimmer Biomet, USA) without stems or augments, and patellar resurfacing was not routinely performed. The primary reason for TKA was osteoarthritis and rheumatoid arthritis. The surgical procedure was identical in all groups. All surgeries were performed using a tourniquet. To prepare the bone standard, cutting guides and jigs were applied; neither robot-assisted surgery nor navigation was used. Exclusion criteria encompassed patients who had undergone TKA following tumor resection, those who had passed away before completing the 4-year follow-up, those requiring the usage of a dummy stem, and patients with evidence of tibial fracture.

During the study period, 856 patients underwent 1039 consecutive primary TKAs. Overall, 22 TKAs were carried out on patients who died before the 4-year follow-up due to irrelevant reasons. Among the rest 1017 TKAs, 29 were conducted in participants who were lost to follow-up, and 988, followed for minimum 2 years, were involved in the study.

The baseline demographic data of the patient (including age, sex, and body mass index [BMI]), the procedure characteristics, and implant information were recorded. The quantity of revision processes was ascertained, and the reason for the revision was noted. For every patient undergoing revision, the case documents were thoroughly examined to ensure that the appropriate coded cause for the revision was noted. In addition, preoperative and intraoperative (ie, the synovial fluid analysis) laboratory tests were reviewed for all patients who underwent revision. To verify whether the cause of the revision was infection or not, we used the Musculoskeletal Infection Society criteria [26]. Patients with radiographic evidence of loosening; symptoms including pain, swelling, or instability; and did not fulfill the Musculoskeletal Infection Society criteria for infection were classified as having aseptic loosening.

Following the surgery, patients underwent regular postoperative assessments at 3 and 6 weeks, followed by evaluations at 3 months and subsequently on an annual basis. To monitor the progress and detect any potential issues, standing anteroposterior and lateral radiographs were initially taken 1 year after the surgery and then at annual intervals or as necessary in response to any emerging problems. The coronal femoral and tibial alignments, hip-knee-ankle, and sagittal tibial alignments were measured on preoperative and postoperative radiographs. We employed the Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System [27] to assess postoperative radiographs. This system involved the examination of radiolucent lines and measuring their widths in millimeters. The components were categorized based on their total scores as follows: inconsequential (score $\leq$ 4), demanding closer clinical observation for progression (5 $\leq$ score $\leq$ 9), or loose (score $\geq$ 10). To identify progressive radiolucent lines, we considered them as such when they appeared on 2 or more sequential radiographs and exhibited either affected a greater zone number or increased severity (width).

Tibial cementing technique

In our conventional cementing technique, a 40-g cement package was used. In this technique, after performing bone cuts, the bone surface was washed without using pulse lavage and then a thick coating of cement was implemented only on the lower surface of the tibia component (including flat surface and the keel). This cementing technique was used in the same way in all patients of the NexGen and Persona nonmodified technique groups, and there was no difference between the cementing technique between these 2 groups.

In our modified cementing technique, the tibial surface is meticulously prepared by irrigating it with pulsed lavage while simultaneously removing clots and fat from cancellous bone tissue cavities. The objective is to create an optimal environment for proper cement penetration. If the tibial canal end is open, it is closed using gel foam covered with surgicel. For cement preparation, 2 40-g packages are used, with one-third transferred to a 50-cc gavage syringe. The cement is injected into the stem hole during its dough phase, ensuring the closed canal prevents leakage. Excess cement is applied thinly on the tibia's upper surface. As cement is injected under pressure, interstitial fluid containing debris is removed simultaneously by suction. The tibial surface is then dried, and a thin layer of cement is applied to the lower surface of the tibial component. Using a particular impactor, the component is positioned and impacted onto the tibia, and any surplus cement is removed. Femoral cementing with the same cement portion was then performed as a 1-stage procedure. Following the installation of the tibial and femoral components, the main polyethylene insert is placed. The knee is then flexed and extended multiple times to remove and clean away any excess cement. Subsequently, the knee is immobilized in full extension for approximately 15 to 20 minutes until the cement has fully cured. Once the cement has set, the retinaculum is sutured in this fully extended position. The instruction for this cementing technique is presented in Table 1.

Statistical analysis

The distribution was normal according to the Shapiro-Wilk test. The Chi-squared test for categorical variables and the one-way analysis of variance for continuous variables performed the comparison between groups. Plotting Kaplan-Meier curves allowed for the evaluation of variations in aseptic revision rates. Log-rank statistic test (Mantle-Cox) was used for between-group comparison. Results were considered significant with a P value of < .05. All statistical analysis was performed using SPSS, version 24 (IBM Corporation).

Table 1
Instructions for modified cementing technique in TKA.

1. Tibial surface preparation:
- Perform tibial surface irrigation using pulsed lavage.
- Simultaneously suction clots and fat from cancellous bone tissue cavities.
- Continue until the bone surface turns white.
- Dry the bone using sterile gauze and suction.
2. Canal closure (if open):
- If the tibial canal end is open, block it with gel foam covered with surgicel.
3. Cement preparation:
- Use 2 packages of 40-g cement for fixation.
- Transfer one-third of the prepared cement into a 50-cc gavage syringe.
4. Cement application:
- When the cement reaches the dough phase, slowly pressurize it into the stem hole using the gavage syringe.
- Ensure the end of the bone canal is closed before cement injection.
- Apply the remaining cement outside the canal as a thin layer on the upper tibia surface.
- As cement is pressurized into the tibia canal, remove interstitial fluid with debris, clots, and fats from the proximal tibia cut using suction.
- Dry the cemented tibia surface with gauze.
5. Tibial component placement:
- Apply a thin layer of cement on the lower surface of the tibial component.
- Place and impact the component onto the tibia using the manufacturer's specific component impactor.
- Wipe away excess cement.
6. Limb immobilization:
- After embedding the main polyethylene, immobilize the limb in full extension for 15-20 min.
- Ensure the cement becomes completely rigid and dry.

TKA, total knee arthroplasty.

Results

Overall, 988 TKAs were performed in the study period with 261 NexGen tibial components, 305 Persona (Zimmer Biomet) tibial components with our conventional cementing technique, and 422 Persona (Zimmer Biomet) early (during the first 24 months) tibial components with our modified cementing technique. The mean follow-up was 89.26 ± 7.32 months. Preoperative and postoperative alignment, age, gender, and BMI were similar among the groups (Table 2).

During this 8-year follow-up, due to aseptic tibial loosening, there were 3 revisions in the NexGen group, 21 revisions in the conventionally cemented Persona (Zimmer Biomet) group, and 4 revisions within the modified cemented Persona (Zimmer Biomet) group (Table 3). Every patient required revision on account of aseptic loosening reported a period of painlessness after the initial surgery and the gradual onset of start-up pain aggravated by weight bearing. Three cases of patients in the conventionally cemented Persona (Zimmer Biomet) group complained of subjective knee instability. Physical examination in these patients showed coronal plane laxity and knee effusion. Unipolar tibial revision was the method conducted in all cases. The femoral component was well fixed in all knees, and there was no evidence of macroscopic polyethylene wear. In all patients, the tibial component was noticeably loose, and in all these cases, failure ensued at the bone-cement interface.

The revision rate at 8 years was 1.1% in the NexGen cohort, 6.9% in the conventionally cemented Persona (Zimmer Biomet) cohort, and 0.9% in the modified cemented Persona (Zimmer Biomet) cohort. The revision rate for early (during the first 24 months) aseptic loosening was 4.6% in the conventionally cemented Persona (Zimmer Biomet) group. However, none of the patients who received NexGen tibial components with nonmodified technique and Persona (Zimmer Biomet) tibial components with modified cementing technique underwent a revision for early (during the first 24 months) aseptic loosening. The revision rates for the conventionally cemented Persona (Zimmer Biomet) group were statistically significantly higher for both periods (both $P < .001$). The mean times to reoperation and aseptic tibial loosening leading to failure based on the time frame of occurrence are presented in Table 3.

The Kaplan-Meier survivorship for aseptic loosening was 98.9% in the NexGen group, 93.1% in the conventionally cemented Persona (Zimmer Biomet) group, and 99.1% in the modified cemented Persona (Zimmer Biomet) group at 8 years. A pairwise comparison using a log-rank test was run. Although survival distributions for the conventionally cemented Persona (Zimmer Biomet) group at 8 years were significantly lower (NexGen, χ^2 [2] = 12.34, $P < .001$; modified cemented Persona [Zimmer Biomet], χ^2 [2] = 11.69, $P < .001$), there was not a significant difference between survival distributions for the NexGen group and the modified cemented Persona (Zimmer Biomet) group at 8 years (χ^2 [2] = 2.48, $P = .116$). The hazard ratio (and confidence intervals [CIs]) between the conventionally cemented Persona and modified cemented Persona (Zimmer Biomet) group is 4.181 (1.768-9.887), stating that aseptic loosening requiring revision is statistically less likely in the modified cemented Persona group than the conventionally cemented Persona (Zimmer Biomet). Survivorship for early (during

Table 2
Demographic data for the study groups (alignment: −: varus; +: valgus).

Variables	NexGen (N = 261)	Persona without modified cementing technique (N = 305)	Persona with modified cementing technique (N = 422)	*P* value
Age	67.97 ± 12.03	67.53 ± 10.47	67.98 ± 11.01	.846
Female gender	192 (73.6%)	237 (77.7%)	322 (76.3%)	.507
BMI	31.45 ± 8.17	30.65 ± 7.24	31.07 ± 7.34	.452
Preoperative alignment	−5.54 ± 11.70	−5.77 ± 13.50	−5.86 ± 12.12	.950
Postoperative alignment	−0.79 ± 1.89	−0.78 ± 1.91	−0.76 ± 1.99	.970
Mean follow-up (months)	92.74 ± 6.88	91.38 ± 7.64	85.58 ± 5.45	.001

BMI, body mass index.

the first 24 months) aseptic loosening was 95.4% in the conventionally cemented Persona (Zimmer Biomet) group, and 100.0% in the NexGen and modified cemented Persona (Zimmer Biomet) group at 2 years.

In our analysis of 960 TKAs without reoperation requirements, radiolucent lines were identified in the most recent radiographs of 124 patients, constituting approximately 12.92% of the total cases. Table 4 presents a breakdown of the frequency of radiolucent lines by group and location. In this study, the conventionally cemented Persona (Zimmer Biomet) group had notably higher radiolucent lines than the other 2 groups, especially in the tibia component ($P =$ .001), when compared to the other 2 groups.

Furthermore, radiolucent lines were noted to have progressed in 1 patient in the NexGen group (0.38%), 7 patients in the conventionally cemented Persona (Zimmer Biomet) group (2.3%), and 1 patient in the modified cemented Persona (Zimmer Biomet) group (0.24%). The conventionally cemented Persona (Zimmer Biomet) group displayed a significantly higher rate of progressive radiolucent lines in comparison with the other 2 groups (P = .026). However, in all other patients, no components were deemed to be concerning as indicated by Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System scores of ≤ 4. No considerable difference was perceived between the other 2 groups in terms of radiolucent lines.

Discussion

Recently, a growing concern has arisen regarding the aseptic loosening of tibial components in patients enduring TKA with shorter tibial baseplate keels. Several studies have implicated elevated levels of stress on the underlying implant surface (the cancellous bone in the proximal tibia, the cement, and the implant interfaces) as a major risk factor for loosening [28,29]. Aseptic loosening of the tibial component continues to be the primary cause of TKA failure and may be linked directly or indirectly to micromotion [30]. Micromotion at the bone-cement or implant-cement interface generates wear particles, which, in the mid-term and long-term follow-up, are determined to be the foremost cause of aseptic loosening [15]. The main causes of mechanical failure in implant fixation during short-term follow-up are either an inadequate cement-implant bond or an overloaded bone-cement contact. Thus, the primary fixation is essential to ensuring the longevity of the prosthesis. Taking into account the stem configuration, stemmed baseplates have a greater fixation area, which gives the implant greater stability and reduces tilting forces in deep flexion.

Shorter native tibial baseplate keels may have an unknown effect on aseptic loosening susceptibility. Several studies, including those conducted by Yoshii et al. [31] and Kraemer et al. [32], which employed preserved cadaveric tibial specimens to investigate the influence of a central stem and its length on micromovement in cementless tibial trays, shed light on this matter. Their findings indicate that tibial implants with stems contribute to a reduction in lift-off, subsidence, and movement in both sagittal and frontal planes. Similar outcomes have been observed in cases involving cemented tibial baseplates. In a retrospective analysis by Kajetanek et al. [3], individuals who garnered a “mini-keel” tibial component were compared to those who were given the standard keeled component of the identical implant layout (Nexgen LPS-Flex; Zimmer Biomet). Their results, after a median follow-up of 5 years, revealed a significantly higher revision rate in the group with mini-keel compared to the group with the standard keeled (5.7% vs 1.6%, respectively; P = .036). Although they proposed that this increased revision rate might be linked to the additional interface between the plate and keel in the mini-keel design, the precise reason of failure in this cohort remained elusive.

This study focused on investigating the effectiveness of using a modified cementing technique based on the total hip arthroplasty cementing technique to reduce the rate of aseptic tibial loosening in Persona implants within 8 years of implantation. We verified our hypothesis of decreased rates of aseptic tibial loosening in the modified cemented Persona group at 8 years compared to the conventionally cemented Persona group. Additionally, we demonstrated that the utility of shorter-keel Persona tibial components with our modified cementing technique was associated with comparable results to NexGen tibial components. No substantial variations were observed between the groups regarding demographic data (including age, gender, BMI, preoperative alignment, and postoperative alignment), which could account for this difference.

Table 3
Causes of surgical revision.

Variables	NexGen (N = 261)	Persona without modified cementing technique (N = 305)	Persona with modified cementing technique (N = 422)	*P* value
Early aseptic loosening (during first 24 mo)	0	14 (4.6%)	0	.001
Month	-	19.14 ± 4.38	-	-
Late aseptic loosening (after 24 mo)	3 (1.1%)	7 (2.3%)	4 (0.9%)	.289
Month	69.00 ± 2.65	65.43 ± 6.35	68.50 ± 3.42	.507
Total aseptic loosening	3 (1.1%)	21 (6.9%)	4 (0.9%)	.001
Month	69.00 ± 2.65	34.57 ± 22.90	68.50 ± 3.42	.003

Table 4
Number of radiolucent lines were observed.

Frequency of radiolucent lines	NexGen (N = 258)	Persona without modified cementing technique (N = 284)	Persona with modified cementing technique (N = 418)	*P* value
Radiolucent line observed	23 (8.91)	62 (21.83)	39 (9.33)	.001
Tibia only	15 (65.22)	48 (77.42)	26 (66.67)	.001
Femur only	5 (21.74)	8 (12.9)	9 (23.08)	.838
Both femur and tibia	3 (20)	6 (12.5)	4 (15.38)	.474
Patients with progression of radiolucent lines	1 (0.38)	7 (2.3)	1 (0.24)	.026

Comparing our results to the existing literature is demanding. The use of Persona Knee System in the reported literature has been associated with controversial and sometimes contradictory results. In some of these articles, it can be challenging to determine exactly what technique was used for cementing [16,19,20]. For example, the overall implant survival was reported at 97.0% (98.2% implant-related) for the Persona Knee System at 2 years in Galea et al. [16] study. They also equate patient-reported outcomes of the Persona Knee System to those of the NexGen Knee System and reported outstanding clinical results, similar to or better than the NexGen Knee System, at early follow-up.

Garceau et al. [20] reported an increased rate of tibial aseptic loosening on a 4-year Kaplan-Meier survival analysis in patients without a stemmed tibia (71.4%, 95% CI: 37.8-100) compared to those with a stemmed tibial component (100%). The study results indicated a significant association between aseptic loosening and the use of a nonstemmed tibial implant. This correlation was potentially linked to the existence of a short natural stem attached to the tibial component. Consequently, the researchers suggested a potential modification to this implant design. In 2021, Yang et al. [19] investigated the initial radiological and clinical results of 720 individuals who underwent Persona Total Knee surgery with a follow-up for at least 2 years. They reported 7 (1.0%) cases of aseptic loosening with a survivorship of 99.6% (95% CI: 99.1%-100.0%) at 3 years and 99.1% (95% CI: 98.4%-99.9%) at 5 years for aseptic loosening. In their study, the researchers did not observe any cases of aseptic loosening among individuals underwent stem augmentation. However, in contrast to the results of Garceau et al., they did not identify a statistically meaningful association between the utilization of stem and the incidence of aseptic loosening. An important point to note in relation to these studies is that the cementing technique has not been elucidated as a prominent factor in reducing the occurrence of aseptic loosening in these studies.

Yang et al. [19] reported a relatively high prevalence of radiolucent lines (67 [9.05%] of the 740 knees); most (65, 99.7%) were nonprogressive and did not require further surgery. In our study, the conventionally cemented Persona group had considerably more radiolucent lines than the other 2 groups (21.83% compare to 8.91% and 9.33%). They also had significantly higher radiolucent lines in tibial component. Furthermore, radiolucent lines seem to progress in 7 cases in the conventionally cemented Persona group (2.3%) and at the implant-cemented interface failure arises.

Sufficient cement thickness and penetration are essential in preventing implant micromotion which is often linked to cement penetrating cancellous bone by less than 1.5 mm, and increasing the bone-cement interface's shear and tensile strength [33,34]. The implant, however, exhibited excellent stability assuming the cement mantle underneath the tibial baseplate was enhanced to 3 mm [35]. A penetration between 3 and 5 mm seems ideal since thermal injuries happen more with penetration more than 5 mm [36]. There needs to be more clarity about the ideal approach of applying cement to the tibial component in cemented total knee replacement.

Recognizing that the cementation technique can participate in aseptic loosening is significant, especially in the absence of consensus on optimal practices, technique standardization, and proper documentation. Scientific data suggest that aseptic tibial loosening, which arises from tibial implant detaching from the cement interface, may be significantly impacted by the type of cement (high viscosity) and the application techniques [30,37,38]. There are several ways in which the surgeon can apply cement—from completely cementing the plateau and the hole created for the stem to cementing only the plateau. Few studies have suggested long-term stability, reduced micromovement potential, and improved fixing are all benefits of complete cementation. Findings showed that, with the exception of cases where the cement mantle underlying the tibial tray was extended to a depth of 3 mm, implant stability frequently enhanced when cement encircled the tibial stem [35,39]. However, this could lead to complications and redundant cement in the proximal tibia during revision surgeries. However, supporters of surface cementing assert that the component is adequately stable and the proximal tibial corticocancellous cut surface is sufficiently loaded to preserve bone density and architecture [10,40]. Opponents criticize surface cementing for its inadequate seal and inadequate fixation [41]. In 2011, Vanlommel et al. [30] compared 5 cementing techniques using 10 g and 20 g of cement on the tibial component's bottom surface in thin and thick layers, applying 20 g of cement on both tibial bone and tibial component by spatula or finger packing method, and using cement gun to implement 20 g of cement to the tibial bone. Their results showed that an optimal cement penetration of 3 to 5 mm could be achieved by applying cement either by spatula or finger-packing to the undersurface of the tibial baseplate and onto the bone surface. When only applied to the tibial component, the penetration of cement is inadequate. The penetration of cement when using a gun is too excessive. In 2022, Cox et al. reported that patients experiencing implant loosening at the cement-bone interface exhibited a noticeably thinner cement mantle compared to those with loosening at the implant-cement interface. The authors suggest that strategies to reduce tibial implant loosening should primarily aim at enhancing fixation at the implant-cement interface [42].

Various factors pertain to the preparation and utilization of cement in TKA, notably the cement's phase during application. In an investigation performed by Silverman et al., an examination of cement penetration at different phases revealed the highest penetration during the dough phase. This finding led them to propose that applying cement during this specific set phase might reduce the risk of aseptic loosening. Prior to pulsed lavage, it is advisable to conduct perforation or drilling the sclerotic bone to ensure the thorough removal of bone debris. Additionally, blood existence within the interface between cement and bone may lower shear strength as much as 50% [9]. This step has been demonstrated to enhance cement penetration and reduce radiolucent lines at both 1-year and 2-year follow-ups when using larger diameter (4.5 mm) bits [43]. For the ultimate preparation of the bone-cement interface, pulsed lavage is considered the optimal method. Studies conducted by Schlegel et al. [44,45] have underscored the critical role of bone preparation and pulsed lavage in improving fixation strength, and they advocate it as a compulsory procedure for surface preparation when cementing tibial components in TKA. Eventually, Hen et al. [46] discovered that employing pressurization and adopting a bisurface cementation method effectively diminishes the incidence of premature loosening adjacent to the femoral component. They attribute this outcome to the crucial role played by the initial cement fixation.

In the final step of our cementing technique, after the tibial and femoral components are installed, the primary polyethylene insert is positioned and the knee is immobilized in full extension for approximately 15-20 minutes to allow the cement to fully cure. Once cured, the retinaculum is sutured with the knee in this extended position. Recently, J. R. Martin et al. highlighted that knee motion during cement polymerization significantly reduces the fixation strength of tibial implants. Their findings showed a decrease in implant pull-out strength with motion across various implant designs. Based on their results, they recommend minimizing knee motion during cementing to enhance tibial implant fixation strength [47].

While a number of factors can separately affect implant loosening, the method of applying cement to the implant and bone is the crucial component linking them all together. It is our belief that due to lack of comprehensive technique data in database analysis, this aspect might not be sufficiently examined by surgeons and manufacturers and may be underevaluated in survivorship studies. In this study, we modified our cementing method to bisurface cementing to prevent aseptic tibial loosening using the Persona Knee System. This modification reduced the number of aseptic tibial loosening cases using the Persona Knee System compared to our conventional cementation method and achieved similar results to the prosthesis with a longer keel (NexGen Knee System). Employing this cementing method to reduce aseptic tibial loosening in the Persona Knee System prosthesis offers significant benefits, including enhanced implant longevity and several other design advantages. These advantages encompass improved bone stock preservation—a crucial benefit for potential future revision surgeries—finer polyethylene insert increments, and an asymmetric, side-specific tibial component design, which may enable a more precise fit and reduce tibial tray overhang.

This study has several limitations.

1. It was subjectively decided whether to conduct surgical revision derived from the patient's symptoms, an X-ray interpretation, and the experience of the surgeon.
2. This study was retrospective in design; however, only 43 of 856 patients (5.02%) were lost to follow-up. Furthermore, due to independent evaluation standards (surgical revision) and comprehensive preoperative data collection, no memory bias in this study existed. Also, for investigating higher revision rates, registry studies should be conducted.
3. For better decision-making, studies with greater number of participants should be performed.
4. Moreover, the reproducibility of the radiographic measurements, factors such as rheumatoid arthritis, osteoporosis, years of suffering, and BMI were not evaluated.
5. One limitation of this study is that we did not analyze the potential impact of tibial baseplate size and keel length on loosening rates within the Persona group. Future research should investigate whether variations in implant size, particularly keel length, influence the incidence of tibial loosening.

Conclusions

Based on our observations, the mid-term results of using the meticulous cementing technique while using tibial components with shorter keel, such as Persona in TKA, represented a revision rate as a reason of the aseptic loosening similar to the NexGen prosthesis with the standard keel. This method can solve the drawback caused by less fixation while benefiting from the advantages of these prostheses. Further clinical trial investigations are required to determine whether using a more precise cementing technique can reduce the rate of aseptic loosening at long-term surveillance with this shorter-keeled contemporary style.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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Ethics approval and consent to participate

These investigations were fully approved by the Institutional Research Ethics Committee School of Medicine-Tehran University of Medical Sciences.

Availability of data and materials

The datasets generated and/or analyzed during the present study are available from Hossein Nematian (hosseinnematian76@gmail.com) on reasonable request.

CRediT authorship contribution statement

Arash Sharafat Vaziri: Writing – review & editing, Writing – original draft, Validation, Supervision, Formal analysis, Conceptualization. **Mohammad Naghi Tahmasebi:** Writing – review & editing, Data curation, Conceptualization. **Hoseinali Hadi:** Writing – review & editing, Validation, Data curation, Conceptualization. **Sina Javidmehr:** Writing – review & editing, Supervision, Formal analysis, Conceptualization. **Sohrab Keyhani:** Writing – review & editing, Writing – original draft, Formal analysis. **Zahra Vahdati:** Writing – review & editing, Writing – original draft, Validation, Conceptualization. **Hossein Nematian:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Yalda Farahmand:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization.

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