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Correlation of post-operative anterior knee pain in two different total knee arthroplasty techniques: the conventional instrumentation (CI) and the patient specific instrumentation (PSI).

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ABSTRACT

Purpose: Evaluation of the clinical outcome, as assessed by the Visual Analogue Scale score and clinical questionnaires, in total knee arthroplasty undertaken with patient specific or conventional instrumentation.
Methods: This is a prospective comparative clinical study of 115 consecutive patients who underwent total knee arthroplasty in two different orthopedic centers. Patients were assessed using the 0-10 Visual Analog Scale in different activities, the Tegner -Lysholm Functional Score, the Knee Society Scores (KSS), measured preoperatively and at 3-6-12 months postoperatively.
Results: Both groups improved significantly over time on all score clinical outcomes. Statistically significant differences were observed between the two groups in the KSS knee score postoperatively at 6 and 12 months (p=0.007 and p=0.004 respectively), and in the Tegner- Lysholm score only at 6 months postoperatively (p=0.001), both in favour of patient specific intrumentation group. The mean KSS was 91.32±4.29 and 93.15±4.72 for the conventional and patient specific groups respectively at 12 months follow up (p=0.063). No statistically significant difference was found at 12 months between two groups when the visual analog scale was measured related to the activity of standing up from the sitting position (conventional group: 1.15±0.36 versus patient specific: 1.10±0.30, p=0.380).
Conclusion: We did not find major significant differences for pain scores, functional scores and clinical out-

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comes between the conventional instrumentation and the use of patient specific instrumentation for total knee replacement. The current literature does not suggest patient specific instrumentation techniques as a gold standard. Therefore, patient specific techniques cannot be recommended as a standard procedure and specially in order to minimize the anterior knee pain after total knee arthroplasty.

KEYWORDS: total knee arthroplasty, anterior knee pain, patient specific instrumentation, visual analog scale, Tegner - Lysholm Score, Knee Society Score

Introduction

Patient specific instrumentation (PSI) is a modern technique in total knee arthroplasty (TKA), aiming to facilitate the implant of the prosthesis. PSIs were introduced to increase the accuracy of the surgical technique and avoid issues related to the complexity of the navigation system, such as procedural costs, surgical time, and learning curve. PSI is expected to improve component alignment and positioning, postoperative functional recovery, and patient satisfaction (16,17). The customized cutting blocks of the PSI are generated from pre-operative computer-aided three-dimensional (3D) reconstruction, 3D printing from a disposable template, using computed tomography (CT) or magnetic resonance imaging (MRI), aiming at an accurate intraoperative placement of the cutting blocks and an accurate osteotomy (16,17). A correct surgical plan is mandatory for a good surgical implant. (18,19,23) The PSI guide takes into account any slight deformities or osteophytes and applies preoperative planning for bone resection, using the pre-determined implant size, position, and rotation. PSI is hypothesized to have advantages with respect to improving component alignment, shortening the surgical time and length of hospital stay, and decreasing perioperative blood loss. Many manufacturers have invested in PSIs (19,21,26). Large debates have taken place about this topic during the last years and, now, there is no consensus in the.. current . literature regarding the accuracy and reliability of PSI, as many studies have shown controversial and inconsistent results. (18,20,21,22,24,25,26,27) In a recent comprehensive systematic review and meta-analysis, Gong et al (30) concluded that PSI has advantages for axial alignment of the femoral component, operative time, and perioperative blood loss compared to conventional instrumentation (CI) total knee arthroplasty. However, no significant differences were observed between PSI and CI with respect to the alignment of the remaining components, number of outliers, and length of hospital stay.

As far as we know there is no clinical study comparing especially the postoperative anterior knee pain (AKP) after primary TKA between CI and PSI of the exact same knee prosthesis. Background of the hypothesized less AKP after TKA with patient specific instrumentation were the causal relationship between malalignment and malrotation component mistakes after TKA and more severe amount of AKP on the one hand (41-49), and the already published superiority of the PSI TKA in the coronal and sagittal alignment and component rotation in comparison to the CI TKA on the other hand (50-55).

Materials and Method

They were 53 patients who took part in the study in the first Orthopaedic center between 2015-2016 (group 1) and 62 patients in the second Orthopaedic center between 2017-2018 (group 2) (Figure 1, Table 1). The inclusion criteria were correct prosthetic components alignment (34), complete one-year follow-up scores, X-rays, and surgery performed by the same OP team for each Orthopaedic center, supervised by an Orthopaedic fellow-trained in Joint Replacement Surgery. Exclusion criteria were major postoperative complications, inflammatory systemic disease, impaired cognitive status and inability

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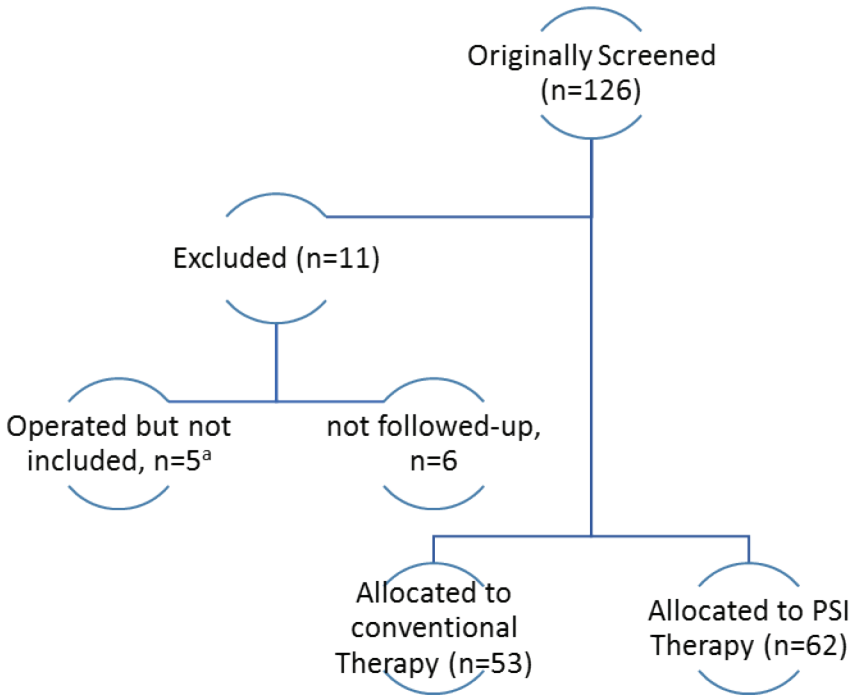

Figure 1 *Flow chart of patients to be considered in this study (a=Not included due to post-operative complications, Haematoma, Fracture, Infection, Iatrogenic Intra-OP mistakes)*

TABLE 1.

Demographic characteristics of patients (SD= standard deviation).

DEMOGRAPHICS		
FACTOR	**Conventional**	**PSI**
NUMBER OF PATIENTS	53	62
MEN/WOMEN RATION	14/39	12/50
AGE (YEARS) MEAN (SD)	70,11 (3,55)	70,35 (3,84)
BMI MEAN (SD)	27,41 (3,10)	25,91 (4,5)
ASA GRADE, NUMBER OF PATIENT		
1	7	3
2	40	50
3	6	9
4	0	0

for follow up. Finally, 11 patients were excluded from the originally 126 registered patients. Written consent was obtained from each patient of each group, after detailed information about the study, and ethical approval was obtained from each respective local ethical committee about this clinical study.

All patients of the study received no patellar pros-

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TABLE 2.

Comparison of Anterior Knee Pain (AKP) at different activities between groups during the observation period

AKP	GROUP	3 MONTHS	6 MONTHS	12 MONTHS	P-VALUE WITH IN GROUP	TIME INDEPENDENT$ MEAN (95%CI)
RAISE FROM A CHAIR	CI TKA	2.74±0.74	1.64±0.74 [a]	1.15±0.36 [a,b]	<0.001	1.84 (1.71-1.98)
	PSI TKA	2.53±0.59	1.55±0.56 [a]	1.10±0.30 [a,b]	<0.001	1.73 (1.60-1.85)
	p-value between groups	0.104	0.444	0.380		0.206
GOING UPSTAIRS	CI TKA	2.45±0.72	1.51±0.75 [a]	1.19±0.39 [a,b]	<0.001	1.72(1.58-1.85)
	PSI TKA	2.39±0.55	1.34±0.54 [a]	1.10±0.30 [a,b]	<0.001	1.61 (1.49-1.73)
	p-value between groups	0.582	0.160	0.158		0.229
GOING DOWNSTAIRS	CI TKA	3,70±0.89	2,36±0.83 [a]	1.32±0.58 [a,b]	<0.001	2,46(2,28-2,64)
	PSI TKA	3,60±0.76	2,39±0.71 [a]	1.32±0.50 [a,b]	<0.001	2,43 (2,27-2,60)
	p-value between groups	0.511	0.843	0.986		0.846
DURING WALKING	CI TKA	2,62±0.81	1,58±0.69 [a]	1.11±0.32[a,b]	<0.001	1,77(1,64-1,91)
	PSI TKA	2,55±0.59	1,58±0.59 [a]	1.05±0.22 [a,b]	<0.001	1,73 (1,60-1,85)
	p-value between groups	0.573	0.972	0.200		0.601

All values are presented as mean ±SD

$ Results based on Two-Way ANOVA model using as factors the intervention and time

[a] P< 0.005 vs 3 months, [b] P< 0.005 vs 6 months

CI TKA : Conventional Instrumentation Total Knee Arthroplasty

PSI TKA : Patient Specific Instrumentation Total Knee Arthroplasty

thesis, but routine intraoperative denervation of the patella with electro cautery and osteophytes removal. All patients received two doses of first-generation cephalosporin preoperatively and 8 h postoperatively. A standard medial parapatellar approach was used for the CI TKA group, where a subvastus approach for the PSI TKA group.

For the control group of the CI, standard intramedullary instrumentation was used for the femoral component. The femoral rotational axis was defined using Whiteside's line, the epicondyle axis, and posterior condylar axis. The tibial component was placed according to the mechanical axis using extramedullary instrumentation. For the study group, the preoperative planning from 3D reconstructed MRI images was performed using planning software (Materialise NV, Leuven, Belgium). The femoral component was set at 3 degrees of flexion. The surgical epi- condylar axis obtained from 3D MRI reconstructed images was used to set femoral rotational reference. The tibial component was planned according to the ideal mechanical axis and with 3 degrees of posterior slope. Intraoperatively, the patient-specific cutting guides were placed on the femur and tibia guiding the bone resection.

The PSI TKA group received 2 g of tranexamic acid (TXA) perioperatively, a standard analgesic cocktail of periarticular, intermuscular und subcutaneous infiltration consisted of Bupivacaine, Morphine-sulfate, Epinephrine, Methylprednisolone diluted in NaCl 0.,9% perioperatively, and a systemic Patient-controlled analgesia for pain management

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TABLE 3.

Comparison of VAS for pain at different sites of the knee joint, between groups during the observation period

VAS	GROUP	3 MONTHS	6 MONTHS	12 MONTHS	P-VALUE WITH IN GROUP	TIME INDEPENDENT$ MEAN (95%CI)
POPLITEAL FOSSA	CI TKA	3,92±0.85	2,49±0.85 [a]	1.53±0.64[a,b]	<0.001	2,65(2,46-2,83)
	PSI TKA	3,85±0.83	2,47±0.74 [a]	1.48±0.62 [a,b]	<0.001	2,60 (2,42-2,77)
	p-value between groups	0.658	0.878	0.706		0.723
MEDIAL SURFACE OF THE KNEE	CI TKA	3,45±0.85	2,15±0.86 [a]	1.28±0.50[a,b]	<0.001	2,30(2,12-2,47)
	PSI TKA	3,55±0.74	2,39±0.71 [a]	1.29±0.49 [a,b]	<0.001	2,41 (2,25-2,57)
	p-value between groups	0.541	0.110	0.947		0.347
LATERAL SURFACE OF THE KNEE	CI TKA	2,72±0.82	1,72±0.66 [a]	1.09±0.30[a,b]	<0.001	1,84(1,70-2,00)
	PSI TKA	3,08±0.77	2,10±0.69 [a]	1.18±0.39 [a,b]	<0.001	2,11 (1,98-2,25)
	p-value between groups	0.016	0.013	0.203		0.006

All values are presented as mean ±SD

$ Results based on Two-Way ANOVA model using as factors the intervention and time

a P< 0.005 vs 3 months , b P< 0.005 vs 6 months

CI TKA : Conventional Instrumentation Total Knee Arthroplasty

PSI TKA : Patient Specific Instrumentation Total Knee Arthroplasty

postoperatively. On the other hand, the patients of the CI TKA group received epidural catheter analgesia until the second postoperative day, and then systemic Patient-controlled analgesia for pain management postoperatively. Both groups received low-molecular-weight heparin for DVT prophylaxis.

The same homogenous rehabilitation protocol for each separate center with an active range of motion exercises and continuous passive motion exercises (CPM) started on the first postoperative day and mobilization with a walker started on the second postoperative day for the CI TKA group. Fast track Knee TKA protocol with CPM motion exercises until full range of knee motion starting in the recovery room at the operation day and mobilization with walker started on the first postoperative day for the PSI TKA group.

Patients were followed up 3 months, 6 months and 1 year postoperatively. The knee pain was assessed between the 2 groups at different sites of the knee joint (Table 3), and the AKP when climbing stairs and standing up from the sitting position (Table 2). Knee function was assessed using KSS Knee and Function Score, and Tegner - Lysholm score (56,57) (Table 4).

Data were expressed as mean±SD or mean±SE (for two way ANOVA analysis results) for continuous variables and as percentages for categorical data. The Kolmogorov-Smirnov test was utilized for normality analysis of the parameters. Homogeneity between compared groups was examined using the Independent samples t-test, Chi-square test and Fisher's exact test. Two-way mixed ANOVA model was used to examine the interaction between "intervention" and "time" factors and compare the variables at each time point and time independently between groups. One factor Repeated Measures ANOVA model was used for the comparison of different time measurements of variables for each

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TABLE 4.

Comparison of Evaluation knee scores between groups during the observation period

SCORES	GROUP	BASELINE	3 MONTHS	6 MONTHS	12 MONTHS	P-VALUE WITH IN GROUP	% CHANGE FROM BASELINE TO		
							3 MONTHS	6 MONTHS	12 MONTHS
VAS	CI TKA	8.55±0.70	4.09±0.90 [a]	2.58±20.86 [a,b]	1.55±0.75 [a,b,c]	<0.001	-52.0±10.5	-69.7±10.1	-81.9±8.6
	PSI TKA	8.34±0.68	3.92±0.77 [a]	2.52±0.74 [a,b]	1.45±0.56 [a,b,c]	<0.001	-53.0±8.7	-69.9±8.2	-82.7±6.2
	p-value between groups	0.107	0.266	0.647	0.437		0.591	0.878	0.533
TEGNER-LYSHOLM	CI TKA	46.42±7.70	65.70±5.61 [a]	72.36±5.81 [a,b]	80.91±4.93 [a,b,c]	<0.001	44.85±24.6	59.60±26.6	78.59±28.88
	PSI TKA	46.24±4.62	66.82±5.63 [a]	76.23±6.50 [a,b]	84.74±5.62 [a,b,c]	<0.001	45.69±17.1	66.10±18.69	84.85±20.1
	$p\text{-value}_{bg}$	0.882	0.287	0.001	<0.001		0.829	0.130	0.175
KSS KNEE	CI TKA	54.45±4.94	71.81±6.50 [a]	78.00±5.08 [a,b]	83.75±4.02 [a,b,c]	<0.001	32.55±13.8	44.11±13.1	54.95±14.72
	PSI TKA	54.60±4.45	74.53±6.80 [a]	80.60±4.95 [a,b]	86.03±4.23 [a,b,c]	<0.001	36.99±13.1	48.33±12.4	58.38±12.38
	$p\text{-value}_{bg}$	0.870	0.031	0.007	0.004		0.079	0.079	0.178
KSS FUNCTION	CI TKA	64.72±6.00	75.66±3.93 [a]	81.98±5.31 [a,b]	91.32±4.29 [a,b,c]	<0.001	17.83±12.0	27.74±14.7	42.37±15.7
	PSI TKA	66.13±46.55	75.16±4.15 [a]	82.26±5.48 [a,b]	93.15±4.72 [a,b,c]	<0.001	14.48±10.2	25.25±11.7	41.95±13.1
	$p\text{-value}_{bg}$	0.234	0.511	0.785	0.063		0.110	0.315	0.875

All values are presented as mean ±SD

[a] P< 0.005 vs baseline , [b] P< 0.005 vs 3 months , [c] P< 0.005 vs 6 months

CI TKA : Conventional Instrumentation Total Knee Arthroplasty

PSI TKA : Patient Specific Instrumentation Total Knee Arthroplasty

intervention. Pairwise multiple comparisons were performed using the Bonferroni test. Comparison of percentage change from baseline to other time points of variables between interventions was analyzed using the Independent samples t-test or Mann-Whitney test in case of violation of normality. All tests are two-sided, statistical significance was set at $p < 0.05$. All analyses were carried out using the statistical package SPSS vr 21.00 (IBM Corporation, Somers, NY, USA).

Results

There is statistically significant reduction of pain during the observation period for both types of surgical instrumentation for all pain variables (p<0.001). There is no statistically significant difference between the two types of surgical instrumentation in relation to absolute values of anterior knee pain at different activities at 3, 6, 12 months and time independently. (Table 2, 3) There was statistically significant lower pain at the lateral only surface of the knee for the CI group compared with the patient specific instrumentation group at 3 months (p=0.016), 6 months (p=0.013) and time independently (p=0.006)

There is statistically significant increase of functional scores during the observation period for both types of intervention (p<0.001). There is no statistically significant difference between the two types of surgical instrumentation in relation to percentile change from baseline to 3, 6 and 12 months of functional scales.

Statistically significant differences were observed between the 2 groups in the absolute values of the KSS Knee score postoperatively at 6 and 12 months, and in the absolute values of the Tegner - Lysholm

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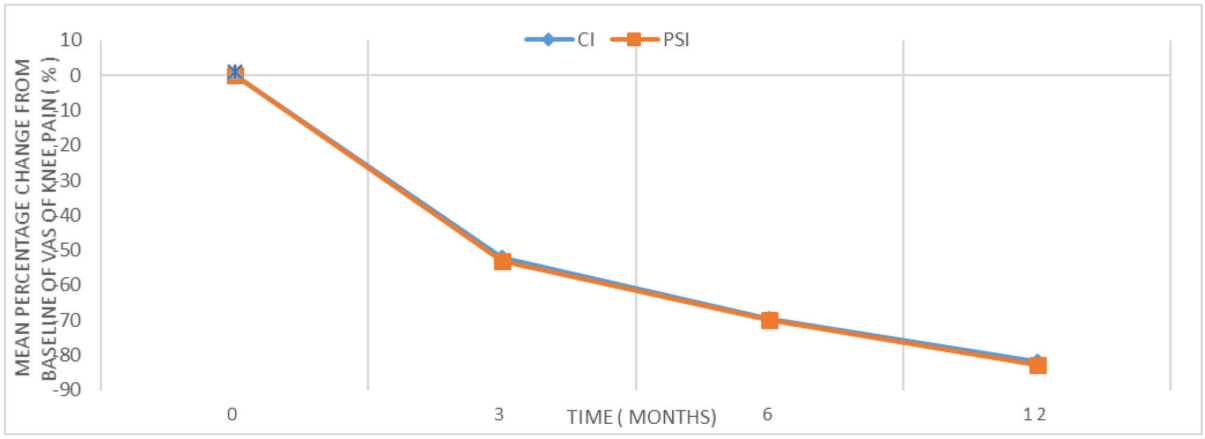

Figure 2 *Mean percentage change from baseline of VAS of knee pain (%).*

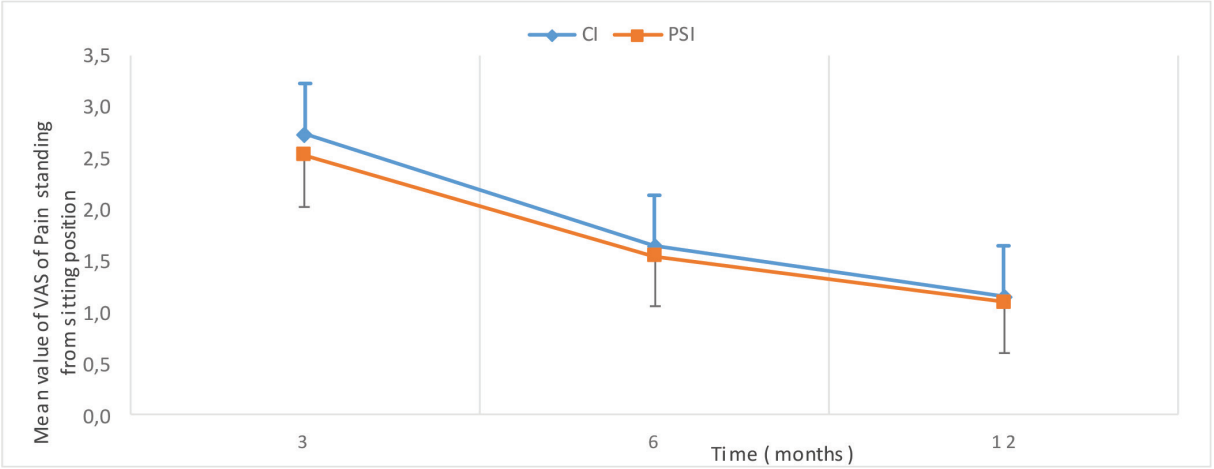

Figure 3 *Mean value of VAS of Pain standing from sitting position.*

score only at 6 months postoperatively, both in favour of the PSI group. (Table 4)

Discussion

The reported incidence of anterior knee pain following primary TKA is 8% (39). Several studies have been conducted to determine the cause of anterior knee pain following TKA with variable results (40). Various causes are responsible for anterior knee pain after primary total knee arthroplasty, such as functional problems due to muscle imbalance, iatrogenic mistakes such as patellofemoral compartment overstuffing, patello-femoral instability or maltracking, different prosthetic design and mainly the design of the femoral component or even patella resurfacing or not strategy (1-15,35,36). Malalignment and malrotation mistakes of the femoral and tibial components play a very important role. Component malalignment following primary TKA has a prevalence ranging between 9.4% and 11.8% (41,42). Isolated internal rotation of the femoral component has been described as a potential source of prosthetic dysfunction, anterior knee pain, and potential early failure (43,44,45). Malrotation of the tibial prosthetic component constitutes another potential cause of a suboptimal clinical outcome following primary TKA (41,43,44). A strong correlation is reported between anterior or medial knee pain and isolated excessive tibial rotation (44). Femoral component rotation also plays a key factor in patellar tracking and can contribute to patellofemoral

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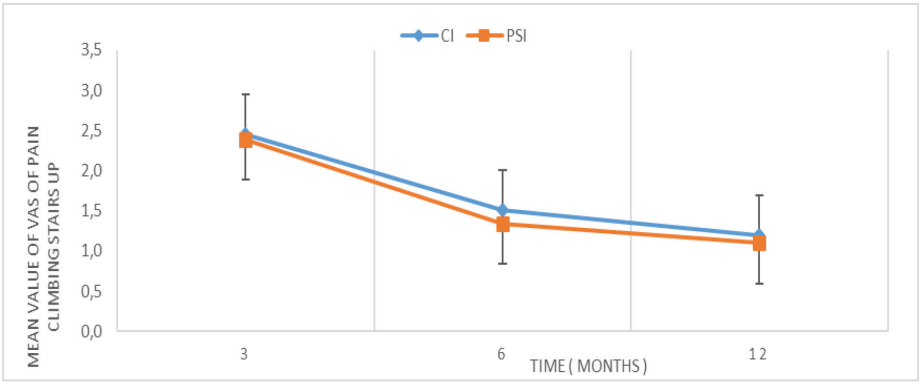

Figure 4 *Mean value of VAS of Pain climbing stairs up.*

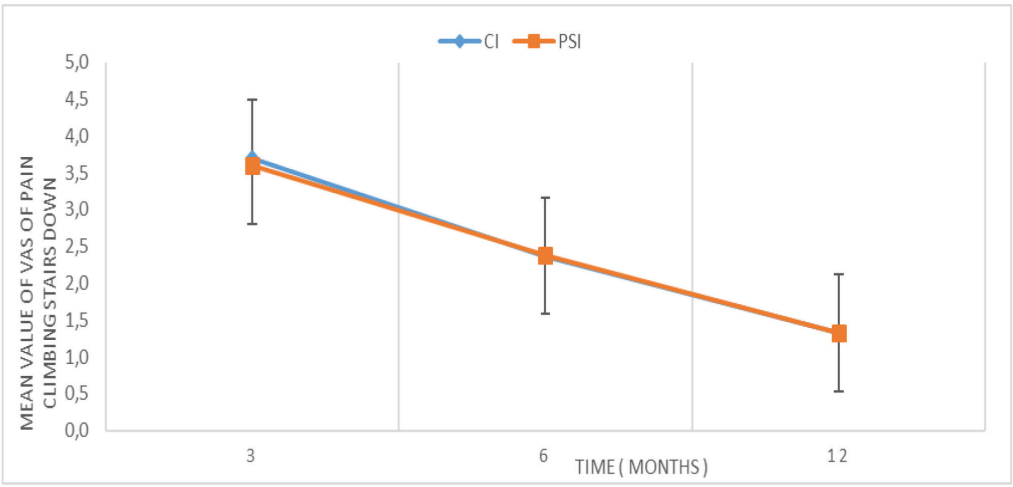

Figure 5 *Mean value of VAS of Pain climbing stairs down.*

complications following TKA. External rotation of the femoral component relative to the posterior femoral condyles facilitates central patellar tracking by reducing patellofemoral lateral shear forces (46,47,48). External rotation of the femoral component leads to lateral positioning of the sulcus and preserves sulcus height, which facilitates a more anatomic orientation of the trochlear groove (49). Therefore it is crucial for TKA systems to have instrumentation that allows for perfect external rotation of the femoral component in order to reproduce a more natural patellofemoral joint (47,49).

The effectiveness of patient specific instrumentation (PSI) compared to that of standard instrumentation (SI) is not completely clear, and the existing data are conflicting. There are studies showing that PSI and SI exhibited significant difference in the coronal and sagittal alignment of the femoral and tibial component (50, 51, 52). Morover other published studies have showed improvement of femoral and tibial rotation in primary TKA with PSI systems in comparison with conventional instrumentation (CI) systems (CI) (53). Khuangsirikul et al (54) and Silva et al (55) showed a more accurate rotational alignment of femoral and of tibial components between custom cutting block (PSI) and CI technique in total knee arthroplasty.

Taking into consideration the causal relationship between malalignment and malrotation mistakes of the femoral and tibial components by primary Total Knee Arthroplasty and Anterior Knee Pain on the

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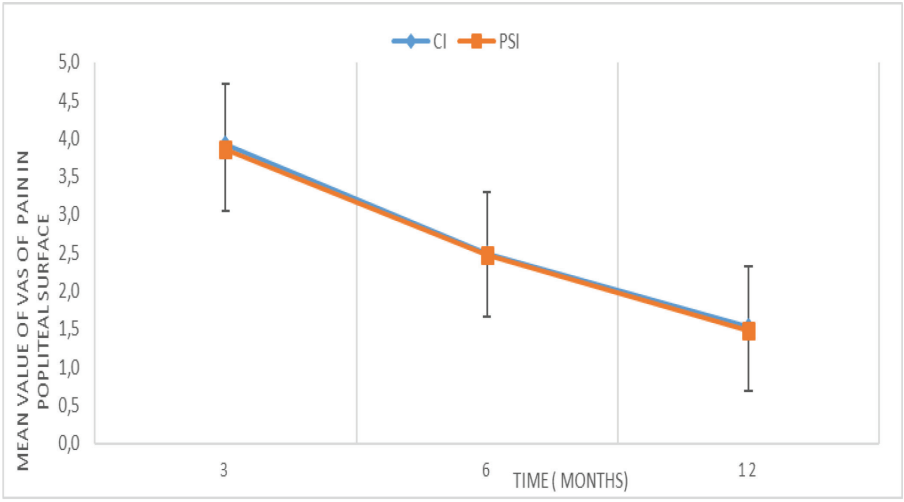

Figure 6 *Mean value of VAS of Pain in popliteal surface.*

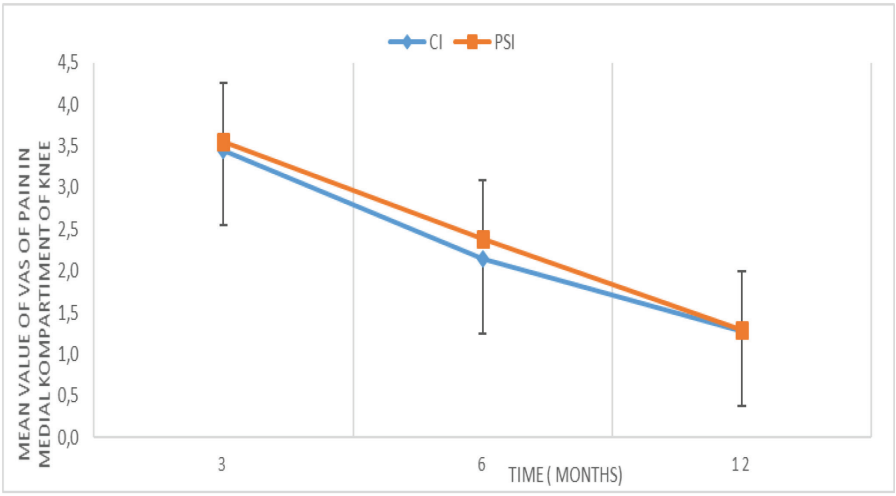

Figure 7 *Mean value of VAS of Pain in medial compartment of knee.*

one hand (41-49), and the already published superiority of the PSI TKA in the coronal and sagittal alignment and rotation of the femoral and tibial components in comparison to the CI TKA on the other hand by several authors (50-55), we hypothesized that PSI would have a better clinical outcome for the postoperative anterior knee pain and in general for patients' satisfaction after primary TKA than conventional Instrumentation, reflected in VAS scores after specific activities and in standard functional knee scores. Thus we compared, between the 2 centers, the exact same Prothesis Nex-Gen CR-Flex Fixed Bearing (Zimmer – Biomet Inc, Warsaw, IN USA), which is already worldwide often implanted, with only difference the PSI planning and PSI surgical technique for the second center. As far as we know there is no clinical study comparing specifically the postoperative AKP after primary TKA between CI and PSI of the exact same knee prosthesis.

The most important finding of this study was that there was no difference in clinical outcome and especially what concerns anterior knee pain after total knee arthroplasty between patient specific and conventional instrumentation 3-6-12 post-operatively, as was hypothesised. We did not find major signifi-

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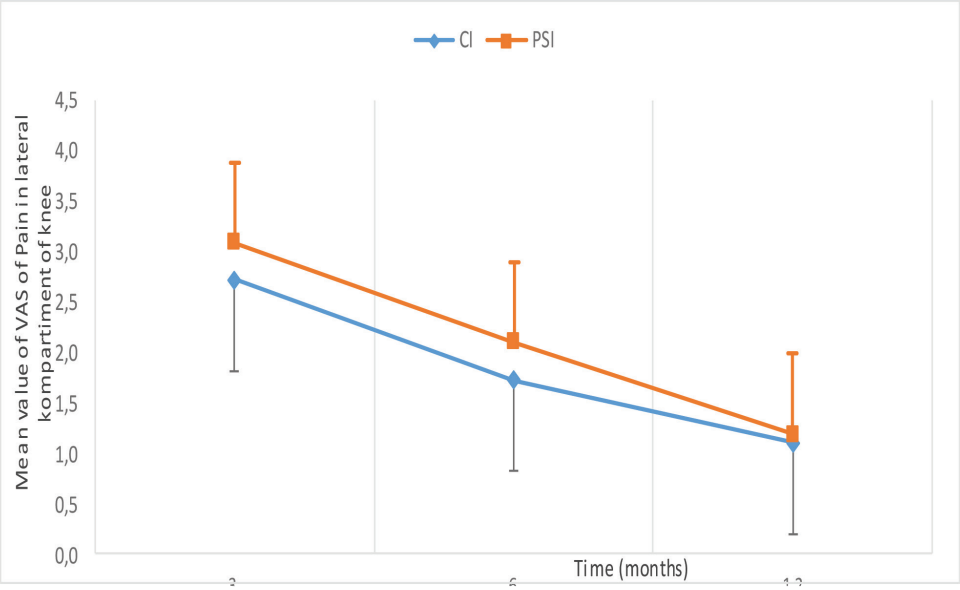

Figure 8 *Mean value of VAS of Pain in lateral compartment of knee*

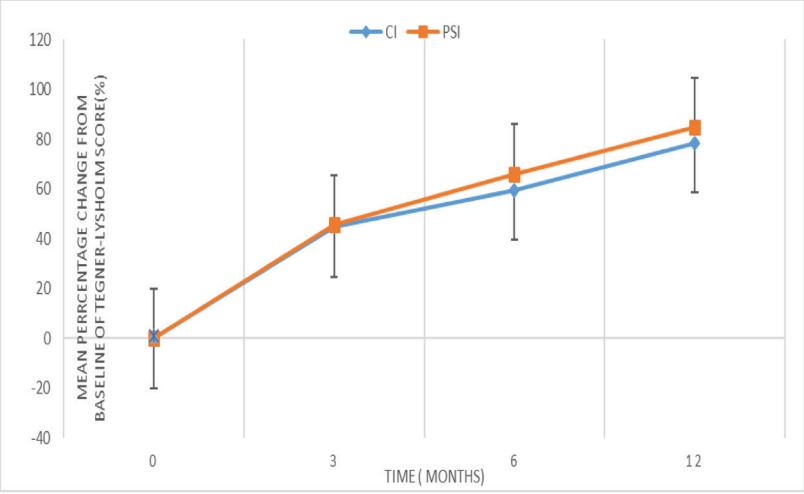

Figure 9 *Mean perrcentage change from baseline of Tegner-Lysholm score (%).*

cant differences for pain scores, knee evaluation scores and clinical outcomes between the conventional instrumentation and the use of patient specific instrumentation for total knee replacement. Our observations concerning the clinical outcome are in line with other authors. Yan et al (62) and Abane et al (63) found no difference in clinical outcome on short-term follow-up. Anderl et al (50) and Chen et al (64) also found no difference in clinical outcome two years post-operatively.

In the present study, we make the hypotheses that patients who underwent a patient specific instrumentation total knee arthroplasty (PSI TKA) would have statistically fewer symptoms of anterior knee pain than those who underwent conventional instrumentation total knee arthroplasty (CI TKA), and generally better clinical improvement reflected in standard knee scores and better subjective satisfaction reflected in VAS scores. Actually, we found no statistically significant difference in VAS

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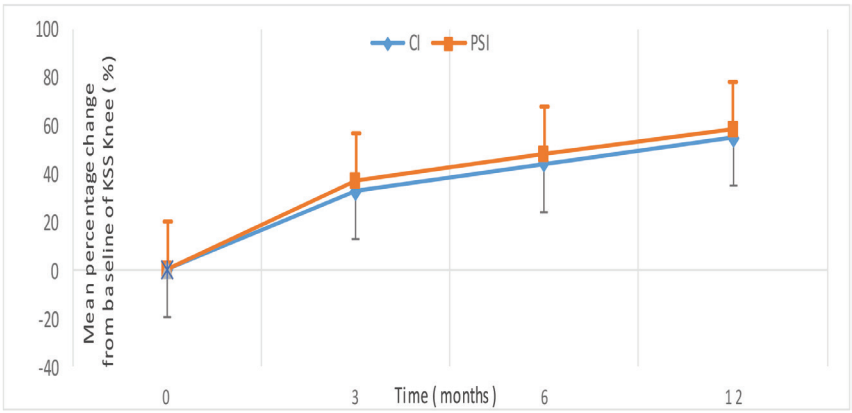

Figure 10 *Mean percentage change from baseline of KSS Knee (%).*

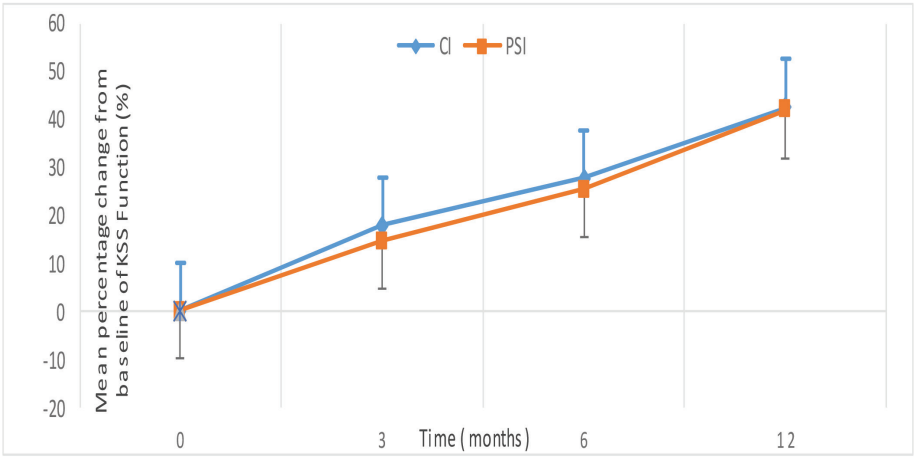

Figure 11 *Mean percentage change from baseline of KSS Function (%)*

score for knee pain (Table 4), in VAS score for the popliteal knee pain (Table 3), and in VAS score for AKP by standing from the sitting position and by climbing stairs (Table 2) between the CI and the PSI TKA group. All the used scores (Tegner Lysholm, KSS Function und KSS Knee) showed no magor difference between the two groups (Table 4). The statistically significant lower pain at the lateral surface for the CI group at 3 months and 6 months postoperativly, and the statistically significant better clinical scores of the KSS Knee score postoperatively at 6 and 12 months, and of the Tegner - Lysholm score only at 6 months postoperatively (both in favour of the PSI group), could be attributed to the lower preoperative BMI score of the patients of the PSI group, and to the more aggressive rehabilitation of the patients of the PSI group (all the patients rehabilitate to special Reha-Clinics, with daily Reha-Sport program). Boonen et al. (32) did not show a significant difference between the conventional and patient specific instrumentation operation when using the Oxford Knee score and did not find a difference for the pain scores also. Woolson et al. (33) did not report any significant difference in range of motion between the 2 operation methods, consistent with our findings. Van Leeuwen J. et al. (31) showed that all KOOS sub-scores and the pain scores were similar between groups of conventional and patient specific instrumentation total knee arthroplasty.

There are limitations to our study. First, the total number of included patients was lower than planned, which was mainly due to problems of follow-up. Second, our study did not compare radiological alignment postoperatively, due to inability

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for postoperatively long leg view and patella axial in the first Orthopaedic center. Third, we assessed no interobserver agreement between the different clinical scores. Forth, the two different Orthopaedic centers used different surgical approaches and different rehabilitation protocols, but still homogenous for each group. Fifth, the data of this study were based on only one type of patient specific instrumentation of one specific company and the findings should therefore not be generalized for other PSI systems. Sixth, the follow up time of one year was relatively short and as a result, no reliable data could be provided on the survival of the TKA in both groups.

The strengths of our study were the double center head to head study design, with homogeneity of demographic and clinical characteristics between compared groups and the fact that same surgeons team for each center respectively, performed the primary knee arthroplasties, implanting exactly the same knee prosthesis of one specific company. Before the study start the surgeons of the second Orthopaedic center were already familiar with the PSI technique.

No clear advantage of PSI seems to exist over conventional instruments. The cost effectiveness of the PSI technique needs to be considered. Potential cost savings include a shortened operating time (51), reduction in the number of sets of instruments (and additional sterilisation costs in most cases), reduced processing time (65). On the other hand, additional costs include the cost of an MRI or CT scans (hospital specific), costs of the patient specific instrumentation (manufacturer and hospital specific), and time needed for logistical tasks, depending on the available personnel. These requirements include the scanning process, transfer of the images to the manufacturer, monitoring the delivery of PSI to the hospital and approval of the digital plan by the surgeon prior to fabrication of the PSI. This last item is essential when using PSI in order to avoid time-consuming intra-operative changes to the proposed size of the components and the levels of resection (66). Literature does not suggest PSI techniques as a gold standard in TKA, and therefore it cannot be recommended as a standard technique and specifically in order to minimize the anterior knee pain (AKP) after TKA. One could only suggest a positive effect of the PSI instrumentation for the less experienced surgeons and in cases of preoperatively femoral or tibia posttraumatic deformities, by minimizing femoral and tibia cutting, without needing intramedullary orientation and therefore minimizing OP time (22,23).

Conclusion

Patient specific instrumentation leads to equal clinical outcome in the short term with no major difference in anterior knee pain and other clinical scores when compared with conventional instruments in TKA surgery. A

REFERENCES

1. Breugem SJ, van Ooij B, Haverkamp D, Sierevelt IN, van Dijk CN. No difference in anterior knee pain between a fixed and a mobile posterior stabilized total knee arthroplasty after 7 years. Knee Surg Sports Traumatol Arthrosc 2014; 22: 509-516
2. Van Jonbergen HP, Reuver JM, Mutsaerts EL, Poolman RW. Determinants of anterior knee pain following total knee replacement: a systematic review. Knee Surg Sports Traumatol Arthrosc 2014; 22: 478-499
3. Ghosh KM, Merican AM, Iranpour F, Deehan DJ, Amis AA. The effect of overstuffing the patellofemoral joint on the extensor retinaculum of the knee. Knee Surg Sports Traumatol Arthrosc 2009; 17: 1211-1216
4. Breugem SJ, Haverkamp D. Anterior knee pain after a total knee arthroplasty: What can cause this pain? World J Orthop 2014; 5: 163-170
5. Bourne RB, Chesworth BM, Davis AM, et al. Patient satisfaction after total knee arthroplasty:

VOLUME 73 | ISSUE 3 | JULY - SEPTEMBER 2022

Who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57-63

6. Kwon SK, Nguku L, Han CD, et al. Is electrocautery of patella useful in patella non-resurfacing total knee arthroplasty? A prospective randomized controlled study. J Arthroplasty 2015;30:2125-7
7. Chen K, Li G, Fu D, Yuan C, Zhang Q, Cai Z (2013) Patellar resurfacing versus non resurfacing in total knee arthroplasty a metaanalysis of randomized controlled trials.IntOrthop37(6):1075–1083
8. Fu Y, Wang G, Fu Q (2011) Patellar resurfacing in total knee arthroplasty for osteoarthritis: a meta-analysis. Knee Surg Sports Traumatol Arthrosc 19(9):1460–1466
9. Patel K, Raut V (2011)Patella in total knee arthroplasty:to resurface or not to. A cohort study of staged bilateral total knee arthroplasty. Int Orthop 35(3):349–353
10. He JY, Jiang LS, Dai LY (2011). Is patellar resurfacing superior than non resurfacing in total knee arthroplasty? A meta-analysis of randomized trials. Knee 18(3):137–144
11. Chonko DJ, Lombardi AV Jr, Berend KR (2004) Patella baja and total knee arthroplasty (TKA): etiology, diagnosis, and management. Surg Technol Int 12:231–238
12. Correia J, Sieder M, Kendoff D, Citak M, Gehrke T, Klauser W, Haasper C (2012) Secondary patellar resurfacing after primary bicondylar knee arthroplasty did not meet patients' expectations. Open Orthop J 6:414–418
13. Garcia RM, Kraay MJ, Goldberg VM (2010) Isolated resurfacing of the previously unresurfaced patella total knee arthroplasty. J Arthroplasty 25(5):754–758. doi:10.1016/j.arth.2009.06.01
14. Muñoz-Mahamud E, Popescu D, Nuñez E, Lozano LM, Nuñez M, Sastre S, Torner P, Segur JM, Maculé F (2011) Secondary patellar resurfacing in the treatment of patellofemoral pain after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 19(9):1467–1472
15. Muoneke HE, Khan AM, Giannikas KA, Hägglund E, Dunningham TH (2003) Secondary resurfacing of the patella for persistent anterior knee painafterprimarykneearthroplasty. J Bone Joint Surg Br 85(5):675–678
16. Camarda L, D'Arienzo A, Morello S, Peri G, Valentino B, D'Arienzo M (2015) Patient-specific instrumentation for total knee arthroplasty: a literature review. Musculoskelet Surg 99:11–18
17. Nam D, Mcarthur BA, Cross MB, Pearle AD, Mayman DJ, Haas SB (2012) Patient-specific instrumentation in total knee arthroplasty: a review. J Knee Surg 25:213–219
18. Alcelik I, Blomfield M, Öztürk C, Soni A, Charity R, Acornley A (2017) A comparison of short term radiological alignment outcomes of the patient specific and standard instrumentation for primary total knee arthroplasty: a systematic review and metaanalysis. Acta Orthop Traumatol Turc 51(3):215–222
19. Cavaignac E, Pailhé R, Laumond G, Murgier J, Reina N, Laffosse JM (2015) Evaluation of the accuracy of patient—specific cutting blocks for total knee arthroplasty: a meta-analysis. Int Orthop 39(8):1541–1552
20. Huijbregts HJTAM, Khan RJK, Sorensen E, Fick DP, Haebich S (2016) Patient-specific instrumentation does not improve radiographic alignment or clinical outcomes after total knee arthroplasty. Acta Orthop 87(4):386–394
21. Jiang J, Kang X, Lin Q, Teng Y, An L, Ma J (2015) Accuracy of patient-specific instrumentation compared with conventional instrumentation in total knee arthroplasty. Orthopedics 38(4):e305
22. Mannan A, Smith TO, Sagar C, London NJ, Molitor PJ (2015) No demonstrable benefit for coronal alignment outcomes in psi knee arthroplasty: a systematic review and meta-analysis. Orthop Traumatol Surg Res 101(4):461–468
23. Qing-Meng Z, Ji-Ying C, Heng L, Wei C, Ming N, Zhen-Dong Z (2015) No evidence of superiority in reducing outliers of component alignment

for patient-specific instrumentation for total knee arthroplasty: a systematic review. Orthop Surg 7(1):19–25

24. Russell R, Brown T, Huo M, Jones R (2014) Patient-specific instrumentation does not improve alignment in total knee arthroplasty. J Knee Surg 27(06):501–504
25. Sharareh B, Schwarzkopf R (2015) Review article: patient-specific versus standard instrumentation for total knee arthroplasty. J Orthop Surg 23(1):100
26. Shen C, Tang ZH, Hu JZ, Zou GY, Xiao RC, Yan DX (2015) Patient-specific instrumentation does not improve accuracy in total knee arthroplasty. Orthopedics 38(3):178–188
27. Thienpont E, Schwab PE, Fennema P (2017) Efficacy of patientspecific instruments in total knee arthroplasty: a systematic review and meta-analysis. J Bone Jt Surg Am 99(6):521
28. Thienpont E, Schwab PE, Fennema P (2014) A systematic review and meta-analysis of patient-specific instrumentation for improving alignment of the components in total knee replacement. Bone Jt J 410(6825):1052–1061
29. Voleti PB, Hamula MJ, Baldwin KD, Lee GC (2014) Current data do not support routine use of patient-specific instrumentation in total knee arthroplasty. J Arthroplasty 29(9):1709–1712
30. Gong S, Xu W, Wang R, Wang Z, Wang B, Han L, Chen G, (2019) Patient-specific instrumentation improved axial alignment of the femoral component, operative time and perioperative blood loss after total knee arthroplasty. KneeSurgSportsTraumatolArthrosc 27:1083–1095
31. Van Leeuwen, J, Snorrason F, Röhr S, No radiological and clinical advantages with patient-specific positioning guides in total knee replacement. Acta Orthopaedica 2018; 89 (1): 89–94
32. Boonen B, Schotanus M G, Kerens B, van der Weegen W, Hoekstra H J, Kort N P. No difference in clinical outcome between patient-matched positioning guides and conventional instrumented total knee arthroplasty two years post-operatively: A multicentre, double-blind, randomised controlled trial. Bone Joint J 2016; 98-B (7): 939-944.
33. Woolson S T, Harris A H, Wagner D W, Giori N J. Component alignment during total knee arthroplasty with use of standard or custom instrumentation: A randomized clinical trial using computed tomography for postoperative alignment measurement. J Bone Joint Surg Am 2014; 96 (5): 366-72
34. Cherian JJ, Kapadia BH, Banerjee S, Jauregui JJ, Issa K, Mont MA. Mechanical, Anatomical, and Kinematic Axis in TKA: Concepts and Practical Applications. Curr Rev Musculoskelet Med 2014; 7: 8995
35. Feller, J.A., Bartlett, R.J., Lang, D.M. Patellar resurfacing versus retention in total knee arthroplasty.J Bone Joint Surg (Br). 1996;78:226
36. Gupta, S., Augustine, A., Horey, L. et al, Electrocautery of the patellar rim in primary total knee replacement: beneficial or unnecessary? J Bone Joint Surg (Br). 2010;92:1259
37. Ranawat CS. History of total knee replacement. J South Orthop Assoc 2002; 11: 218-226
38. Becker R, Bonnin M, Hofmann S. The painful knee after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2011; 19: 1409-1410
39. Petersen W, Rembitzki IV, Brüggemann GP, Ellermann A, Best R, Koppenburg AG, Liebau C. Anterior knee pain after total knee arthroplasty: a narrative review. Int Orthop 2014; 38: 319-328
40. Shervin D, Pratt K, Healey T, et al. Anterior knee pain following primary total knee arthroplasty. World J Orthop. 2015;6:795–803
41. Mulhall KJ, Ghomrawi HM, Scully S, Callaghan JJ, Saleh KJ. Current etiologies and modes of failure in total knee arthroplasty revision. Clin Orthop Relat Res 2006; 446: 45-50
42. Sharkey PF, Lichstein PM, Shen C, Tokarski AT, Parvizi J. Why are total knee arthroplasties failing today--has anything changed after 10 years? J Arthroplasty 2014; 29: 1774-1778

VOLUME 73 | ISSUE 3 | JULY - SEPTEMBER 2022

43. Pietsch M, Hofmann S. Early revision for isolated internal malrotation of the femoral component in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2012; 20: 1057-1063
44. Lakstein D, Zarrabian M, Kosashvili Y, Safir O, Gross AE, Backstein D. Revision total knee arthroplasty for component malrotation is highly beneficial: a case control study. J Arthroplasty 2010; 25: 1047-1052
45. Miller MC, Berger RA, Petrella AJ, Karmas A, Rubash HE. Optimizing femoral component rotation in total knee arthroplasty. Clin Orthop Relat Res 2001; (392): 38-45
46. Chew JT, Stewart NJ, Hanssen AD, Luo ZP, Rand JA, An KN. Differences in patellar tracking and knee kinematics among three different total knee designs. Clin Orthop Relat Res 1997; (345): 87-98
47. Malo M, Vince KG. The unstable patella after total knee arthroplasty: etiology, prevention, and management. J Am Acad Orthop Surg 2003; 11: 364-371
48. D'Lima DD, Chen PC, Kester MA, Colwell CW. Impact of patellofemoral design on patellofemoral forces and polyethylene stresses. J Bone Joint Surg Am 2003; 85-A Suppl 4: 85-93
49. Varadarajan KM, Rubash HE, Li G. Are current total knee arthroplasty implants designed to restore normal trochlear groove anatomy? J Arthroplasty 2011; 26: 274-281
50. Anderl W, Pauzenberger L, Kölblinger R, Kiesselbach G, Brandl G, Laky B, Kriegleder B, Heuberer P, Schwameis E (2016) Patient-specific instrumentation improved mechanical alignment, while early clinical outcome was comparable to conventional instrumentation in TKA. Knee Surg Sports Traumatol Arthrosc 24:102–111. 183
51. Renson L, Poilvache P, Wyngaert HVD (2014) Improved alignment and operating room efficiency with patient-specific instrumentation for TKA. Knee 21:1216–1220
52. Vaishya R, Vijay V, Birla VP, Agarwal AK (2016) Computerized tomography based "patient specific blocks" improve postoperative mechanical alignment in primary total knee arthroplasty. World J Orthop 7:426–433.
53. Mannan A, Smith TO Favourable rotational alignment outcomes in PSI knee arthroplasty: A Level 1 systematic review and meta-analysis. Knee. 2016 Mar;23(2):186-90
54. Khuangsirikul S, Lertcharoenchoke T, Chotanaphuti T (2014) Rotational alignment of femoral component between custom cutting block and conventional technique in total knee arthroplasty. J Med Assoc Thai 97(Suppl 2):S47–S51
55. Silva A, Sampaio R, Pinto E (2014) Patient-specific instrumentation improves tibial component rotation in TKA. Knee Surg Sports Traumatol Arthrosc 22:636–642
56. Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). Arthritis Care Res (Hoboken) 2011; 63 Suppl 11: S208-S228
57. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989; 13-14
58. Cretu BS, Dragosloveanu C, Dragosloveanu S, Cristea S, Radiographic Evaluation of Alignment Following Total Knee Arthroplasty - a Systematic Review. Part II. Maedica (Buchar). 2018 Jun;13(2):105-111.
59. Chia SL, Merican AM, Devadasan B, et al. Radiographic features predictive of patellar maltracking during total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2009;10:1217–1224.
60. Heesterbeek PJ, Beumers MP, Jacobs WC, Havinga ME, Wymenga AB. A comparison of repro-

VOLUME 73 | ISSUE 3 | JULY - SEPTEMBER 2022

ducibility of measurement techniques for patella position on axial radiographs after total knee arthroplasty. Knee. 2007;14:411–6

61. Kohn MD, Sassoon AA, Fernando ND. Classifications in brief: Kellgren-Lawrence classification of osteoarthritis. Clin Orthop. 2016;474(8):1886–1893.
62. Yan CH, Chiu KY, Ng FY, Chan PK, Fang CX. Comparison between patient-specific instruments and conventional instruments and computer navigation in total knee arthroplasty: a randomized controlled trial. Knee Surg Sports Traumatol Arthrosc 2015;23:3637–3645.
63. Abane L, Anract P, Boisgard S, et al. A comparison of patient-specific and conventional instrumentation for total knee arthroplasty: a multicentre randomised controlled trial. Bone Joint J 2015;97-B:56–63.
64. Chen JY, Chin PL, Tay DK, et al. Functional Outcome and Quality of Life after Patient-Specific Instrumentation in Total Knee Arthroplasty. J Arthroplasty 2015;30:1724–1728.
65. Lachiewicz PF, Henderson RA. Patient-specific instruments for total knee arthroplasty. J Am Acad Orthop Surg 2013;21:513–518.
66. Pietsch M, Djahani O, Hochegger M, Plattner F, Hofmann S. Patient-specific total knee arthroplasty: the importance of planning by the surgeon. Knee Surg Sports Traumatol Arthrosc 2013;21:2220–2226

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