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Research Article

New Technique for Simple and Reproducible Gap-Balancing in Total Knee Arthroplasty Using a Modified Spacer Block

Faiz Felemban*, Mohamed Yousef, Mohamed Al Otaibi and Ehab ElZayyat

Department of Orthopedic, International Medical Center, Saudi Arabia

***Corresponding Author:** Faiz Felemban, Department of Orthopedic, International medical center, Saudi Arabia.

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Abstract

Introduction: Total knee arthroplasty (TKA) is used routinely throughout the world to treat advanced osteoarthritis. Establishing symmetrical, balanced, flexion and extension gaps is a vital step in TKA. Precise soft-tissue balance in conjunction with precise bone resection influences the knee implant's stability in flexion and extension and affects functional outcomes. The study aim was to apply a new hybrid gap-balancing technique using modified spacer blocks (10-mm thickness) to TKA. This technique helps to predict femoral cuts, minimize the procedural steps, and determine proper femoral component rotation in a simple reproducible way.

Materials and Methods: We reviewed 20 consecutive patients (12 females and 8 males, mean age of 63.4 years) who underwent TKA for treating osteoarthritis from June to August 2020. All patients were treated using a hybrid gap-balancing technique assisted with a modified spacer block. Postoperative knee function scores were recorded. The follow-up for all patients was a minimum of 6 months and a maximum of 1 year postoperatively.

Results: The mean postoperative knee score was 83.6, the mean postoperative function score was 86, all patients had anterior-posterior and medio-lateral stability of <5 mm, one patient had a flexion contracture of 5°-10°, and 14 of 20 patients could walk without a walking aid. The mean follow-up was 12 months.

Conclusion: The use of a hybrid balancing technique combined with a modified spacer block provided stable knees with great functional outcomes. Higher quality randomized controlled studies are required for a better evaluation of this technique.

Keywords: Total Knee Arthroplasty; Osteoarthritis; Gap Balancing Technique; Modified Spacer Block

Introduction

Total knee arthroplasty (TKA) is a commonly performed procedure that has a high success rate in the treatment of end-stage osteoarthritis [1,2]. Numerous techniques, including conventional TKA, computer-assisted navigation, and robotic-assisted TKA, have been described in the literature, but studies have demonstrated equivalent functional outcomes, surgical times, and aseptic loosening results [3-5]. It is well established that adequate coronal and transverse ligament balancing, along with patellar tracking and component sizing, all affect postoperative outcomes. Almost half of all knee revisions may be avoided with appropriate ligament balance [6-9]. To achieve a well-balanced knee, two primary surgical approaches are used: measured resection and gap balance [10]. The gap-balancing technique is further divided into two types: 1) original gap balance, which balances the extension gap first, and 2) modified gap balance, which balances the flexion gap first. Many surgeons start by balancing the flexion gap. Their idea is that it may help facilitate both the flexion and extension gap, starting with the tibial cut first (which must be accurate) because it will serve as the base for the femoral bone resection. A varus tibial cut results in excessive internal rotation of the femoral component, whereas a valgus resection results in excessive external rotation. A tensioning device, or lamina spreader, is used after the tibial cut to maintain soft-tissue tension in flexion [11-14]. Although other techniques balance the extension gap before the flexion gap, in this technique, the tibial cut is made after starting with the distal femur cut using an intramedullary guide and after removal of osteophytes and tensioning of the soft-tissue in extension [11,13,14]. In the measured resection technique, bone cuts are made independent of soft-tissue tensioning and relies on bony landmarks, such as the transepicondylar axis [15], AP axis [16], and the posterior condylar axis [17]. Currently, there is a debate regarding which technique is superior to the other [11,12].

The study aim was to retrospectively review the application of a new hybrid gap-balancing technique using modified spacer blocks

(10-mm thickness) to patients who needed TKA. With the aid of a spacer block, which we modified with the manufacturer's permission (see Methods section), this technique uses a hybrid approach that combines the strengths of each technique: appropriate implant positioning and alignment in the coronal, axial, and sagittal planes in the measured resection technique and joint conformity in gap-balancing.[5] This technique was highly effective in predicting the femoral cuts (distal and posterior) along with determining femoral component rotation. An additional benefit is that it will help preserve more bone than when using the 9-mm traditional cut and can save time during the procedure and avoid additional steps in recutting the distal femur if the surgeon needs to increase the size of the cut in a simple reproducible way.

Materials and Methods

We conducted a retrospective review of 20 consecutive patients (12 females and 8 males, mean age of 63.4 years) with advanced knee osteoarthritis who underwent TKA between June and August of 2020. All patients included in the study were operated on by the same senior arthroplasty surgeon in the same institution using the Persona® personalized knee system and a plastic spacer block developed by Zimmer Biomet (Warsaw, IN) that was originally 20-mm thick, but we modified it to 10-mm thick with the manufacturer's permission (Figure 1). The mean follow-up was 12 months, and postoperative Knee Society function scores were recorded.

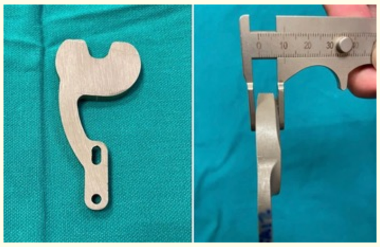

Figure 1: Shown is the Zimmer™ spacer block after reducing it to a 10-mm thickness.

Surgical technique

All surgeries were performed by the same senior arthroplasty surgeon using the posterior stabilizer TKA prosthesis Persona® system and performed through a subvastus approach to the knee. Patients were positioned supine on a regular OR table, and their knees were flexed 90° using a foot support and lateral-side support. We performed sterile prepping and draping and gave 2 g of cefazolin 15 minutes prior to incision and 1g of tranexamic acid IV after exsanguinating the limb and inflating the tourniquet. A straight anterior skin incision was then made with the knee in flexion beginning 5 cm above the patella, carrying it distally just medial and 2 cm distal to the tibial tubercle. An incision was made in the superficial fascia slightly medial to the patella, which was bluntly dissected off the vastus medialis muscle fascia down to the muscle insertion. Then, the inferior edge of the vastus medialis was identified, and blunt dissection of the periosteum and intermuscular septum for a distance of 10-cm proximal to the adductor tubercle was performed. Next, we identified the tendinous insertion of the muscle on the medial patellar retinaculum and elevated the vastus medialis muscle anteriorly, followed by performing an L-shaped arthrotomy beginning medially through the vastus insertion on the medial patellar retinaculum and carrying it along the medial edge of the patella. The medial edge of the patellar tendon was released, and the patella was everted laterally with the knee in extension after removing all of the meniscus and fat pad along with any medial or lateral osteophytes around both the tibia and femur. The knee range of motion was then assessed, and if extension and flexion were limited, 10-12 mm was typically cut from the least affected tibial condyle. If there was no deficit in flexion and extension, 8 mm was removed from the least affected tibial condyle. Next, the spacer block was placed within the gap and then the flexion and extension balance was provisionally assessed (Tables 1-3) (Figure 2-9). Rotation of the femoral component was determined with the aid of the spacer. We applied 3° of external rotation unless it was too tight on the medial aspect, in which case we applied 5° of external rotation (Figure 10).

Extension Gap	Flexion Gap	Action
Loose	Loose	Use thicker PE Or add tibial medial and lateral augment + intramedullary stem (Figure 2)
Loose	Balanced	* Undercut the distal femur e.g., 9 mm to 7 mm (Figure 3)
Loose	Tight	Downsize the femoral component. e.g., size 6 to size 5 or 4 And undercut the femoral component. e.g., 9 mm to 7 mm (Figure 4)

Table 1: After making the tibial cut and inserting the spacer, we assessed the flexion and extension gap and based on the finding

Extension Gap	Flexion Gap	Action
Balanced	Tight	Downsize the femoral component. e.g., size 6 to size 5 or 4 (Figure 5)
Balanced	Loose	upsize the femoral component. e.g., size 4 to size 5 or 6 (Figure 6)
Balanced	Balanced	9mm distal femur traditional cut

Table 2: If the knee was well balanced in extension and tight or loose in flexion we downsized or upsized the femoral component

Extension Gap	Flexion Gap	Action
Tight	Tight	* Cut more proximal tibia (Figure 7)
Tight	Loose	* Cut more distal femur e.g., 9 mm to 11 mm * Upsize femoral component e.g., size 4 to size 5 or 6 (Figure 8)
Tight	Balanced	* Cut more distal femur e.g., 9 mm to 11 mm (Figure 9)

Table 3: When we couldn't reach full extension after inserting the spacer we adjusted the distal femoral cutting jig to 11 mm instead

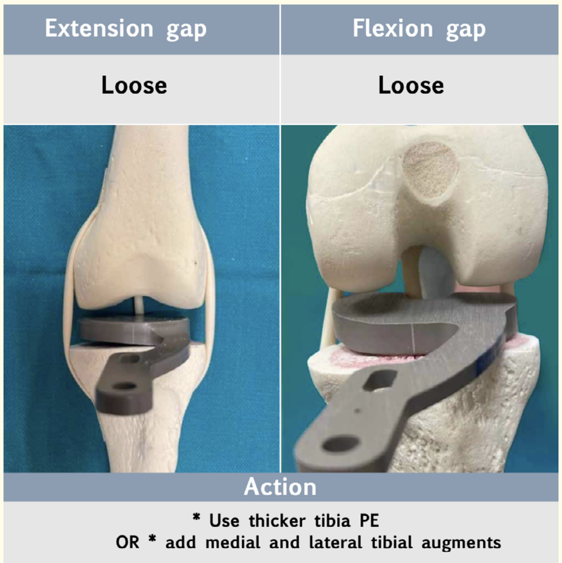

Figure 2: Showing a knee that is loose on both extension and flexion.

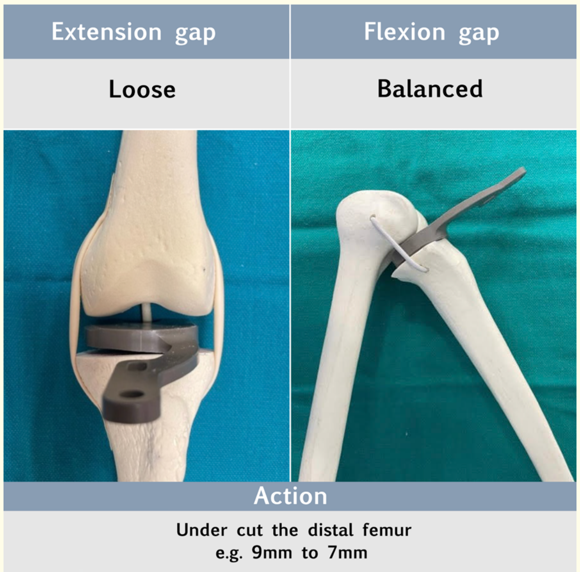

Figure 3: Showing on the left a loose knee in extension but can achieve full flexion in that instance we recommend undercutting the distal femur from 9mm to 7mm.

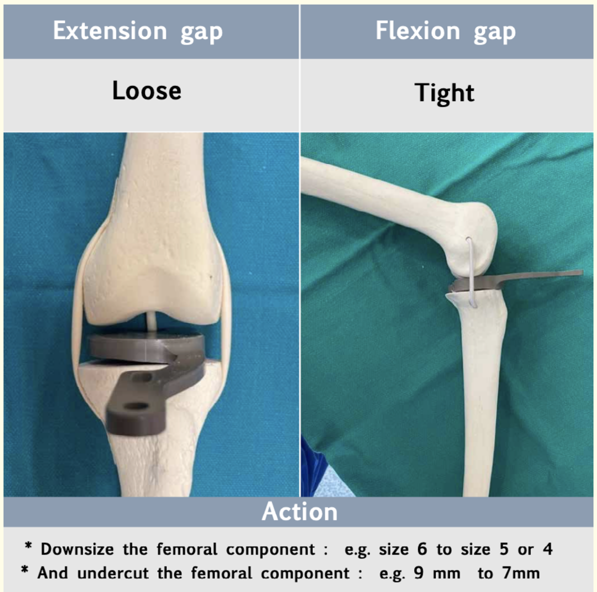

Figure 4: On the left showing loose extension gap, and tight in flexion in that case we recommend downsizing the femoral component to correct the flexion gap and undercutting the distal femur to balance the extension gap.

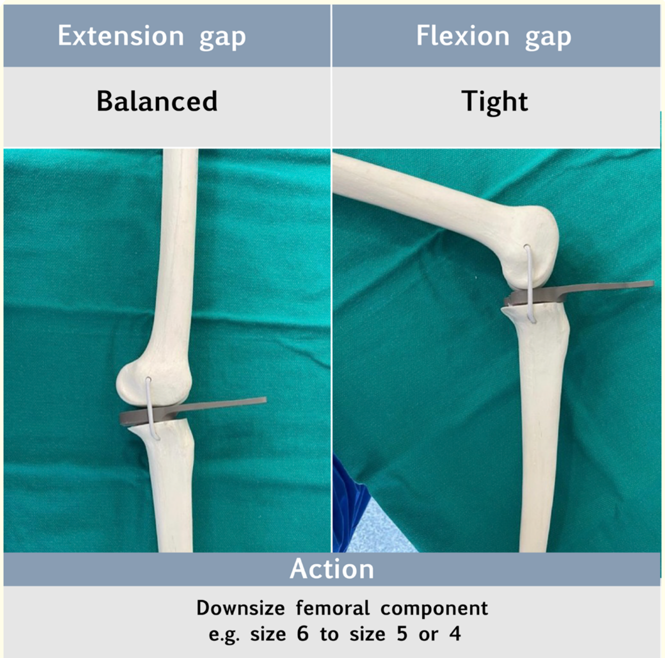

Figure 5: If the flexion gap is tight the authors suggest downsizing the femoral component.

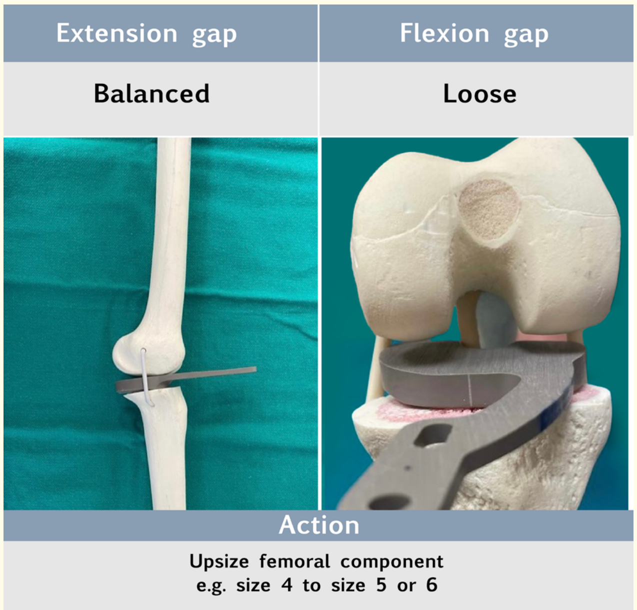

Figure 6: Showing a knee balanced in extension and loose in flexion.

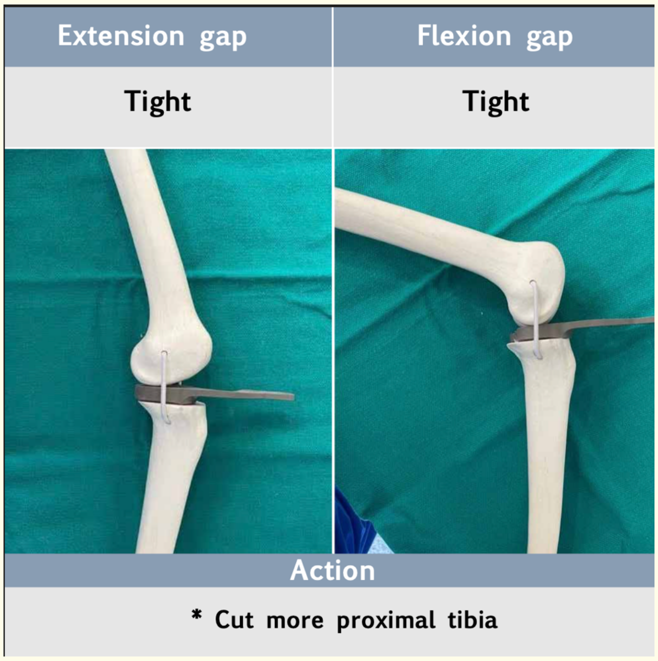

Figure 7: When both gaps were tight then not enough proximal tibia was resected.

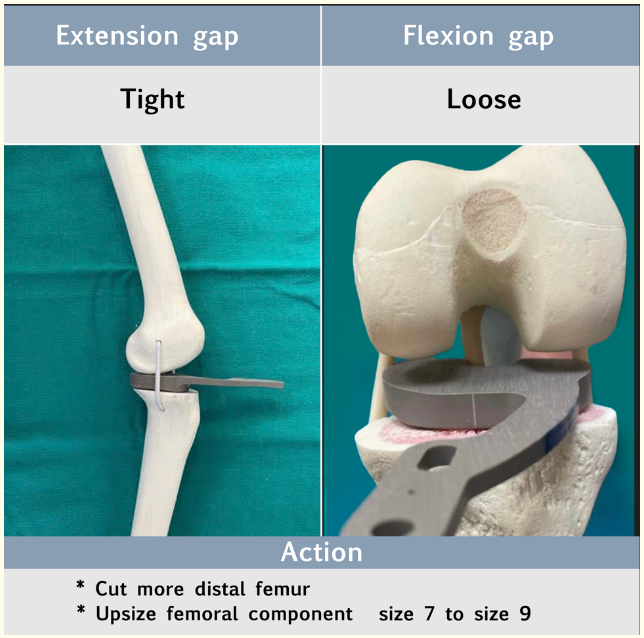

Figure 8: Showing on the left a tight knee in extension and loose in flexion.

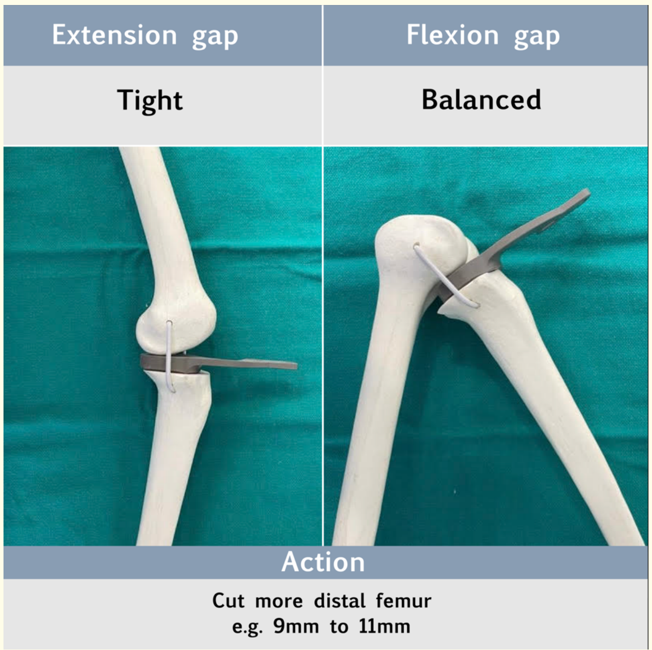

Figure 9: On the left a knee that is tight in extension but well balanced in flexion then a 11mm distal femoral cut resected.

Figure 10: If the spacer was too difficult to insert on the medial aspect, we applied 5° of external rotation.

After making appropriate cuts, posterior condylar osteophytes were excised since they can obstruct flexion and tent posterior soft-tissue structures during extension, resulting in flexion contracture. The bone was prepared to receive the implant by thoroughly washing the joint with normal saline mixed with iodine and antibiotic. Then, antibiotic solution was sprayed over the bone and deep tissue, cement was mixed using negative vacuum pressure, and the excess cement was removed. The range of motion was tested. Almost all of our patients had a polyethylene insert of 10 mm height. The joint was washed using a jet lavage with 2L of normal saline, hemostatic powder was sprayed with 1g of tranexamic acid local and 500 mg vancomycin powder in the wound, the tourniquet was deflated, and hemostasis was maintained with closure of the capsule and tendon with a size-2 Ethibond suture and subcutaneously with Vicryl® 0. The subdermal suture was a Vicryl® 2-0, and a stapler was used for the skin, followed by application of a Mepore dressing and Bence–Jones bandage, which was removed on postoperative day 1 to allow range of motion.

Results

The patients had a minimum follow-up of 6 months and a maximum of 18 months postoperatively. The mean postoperative knee score was 83.6, the mean postoperative functional score was 86, all patients had anterior–posterior stability of <5 mm and medio-lateral stability of 5 mm, 1 patient had a flexion contracture of 5°–10°, and 14 out of 20 patients could walk without the use of a walking aid. One patient complained of persistent anterior knee pain postoperatively (Tables 4,5).

Patient	Pain	Flexion Contracture	Range of flexion	Extension lag	Alignment (°)	Function			Stability		Knee score	Function score
					Varus & Valgus	Walking	Stairs	Walking aid used	Antero-posterior	Medio-lateral		
1	None	0	116-120	0	2	Unlimited	Normal	None	<5 mm	<5°	90	100
2	Mild	0	116-120	0	3	Unlimited	Normal	Cane	<5 mm	<5°	88	95
3	None	0	121-125	0	2	Unlimited	Normal	Cane	<5 mm	<5°	91	85
4	Mild	0	121-125	0	4	Unlimited	Normal	Cane	<5 mm	<5°	92	95
5	None	0	121-125	0	3	>10 blocks	Normal	Cane	<5 mm	<5°	94	85
6	Mild	0	116-120	0	2	>10 blocks	Normal	None	<5 mm	<5°	80	90
7	Mild	0	121-125	0	3	Unlimited	Normal	None	<5 mm	<5°	89	90
8	Mild	0	116-120	0	5-10	5-10 Blocks	Normal	Cane	< 5mm	<5°	94	75
9	Mild	0	116-120	0	5-10	Unlimited	Normal	None	<5 mm	<5°	94	100
10	Mild	0	116-120	0	1	>10 blocks	Normal	None	<5 mm	<5°	82	90
11	Mild	0	116-120	0	4	>10 blocks	Normal with rail	None	<5 mm	<5°	91	70
12	Mild	5°-10°	111-115	<10°	5-10	5-10 Blocks	Normal	None	<5 mm	<5°	86	80
13	Mild	0	116-120	0	1	Unlimited	Normal with rail	None	<5 mm	<5°	82	90
14	Mild	0	116-120	0	0	>10 blocks	Normal	None	<5 mm	<5°	74	90
15	Moderate	0	111-115	0	0	Housebound	With rail	Cane	<5 mm	<5°	43	35
16	Mild	0	121-125	0	0	Unlimited	Normal	None	<5 mm	<5°	80	100
17	None	0	116-120	0	2	Unlimited	Normal	None	<5 mm	<5°	90	100
18	Moderate	0	106-110	0	0	Unlimited	Normal	None	<5 mm	<5°	52	100
19	None	0	116-120	0	2	Unlimited	Normal with rail	None	<5 mm	<5°	90	90
20	None	0	121-125	0	2	<5 Blocks	Normal with rail	None	<5 mm	<5°	91	60
Mean scores					2.3						83.65	86

Table 4: Postoperative Clinical Scores N = 20.

N: 20.

Variables	Number of Patients
Pain:	
None	6
Mild	12
Moderate	2
Flexion Contracture (°)	
0	19
5–10	1
Range of flexion (°)	
106–110	1
111–115	2
116–120	11
121–125	6
Extension lag (°)	
0	19
<10	1
Alignment (°)	
Varus & Valgus	
0	4
1	2
2	6
3	3
4	2
5–10	3
Function:	
Walking	
Unlimited	11
>10 Blocks	5
>5 Blocks	1
5–10 Blocks	2
Housebound	1
Stairs	
Normal	15
Normal with rail	5
Walking aid used	
None	14
Cane	6
Stability	
Antero-posterior (<5 mm)	20
Medio-lateral (<5°)	20

Table 5

Discussion

TKA is a successful procedure for relieving pain and improving function for patients with advanced knee osteoarthritis.[1] However, despite its popularity, a significant number of patients are still dissatisfied after the procedure, and surgeons have not been able to replicate the satisfaction with total hip replacement.[18,19] Patients with a well-balanced knee have been found to have better functional outcomes and higher patient satisfaction than patients with a prosthetic lax knee.[17,20,21,22] Therefore, surgeons are always looking for different and newer techniques to increase patient satisfaction and identify areas of potential improvement in outcomes.

We found that by performing the tibial cut first and inserting a 10-mm spacer block, which resembles the thickness of the tibial base plate and polyethylene combined, this method was highly effective in predicting the distal and posterior femoral cuts and aided in precise femoral component rotation. An additional benefit was that it helped preserve more bone when needed and avoided excess bone resection while avoiding extra steps in the recutting procedure. All patients included in the study had a polyethylene insert of 10-mm thickness. Patients examined at follow-up for evidence of laxity defined by opening of the joint from antero-posterior and medio-lateral, none of them had a laxity of more than 4 mm, which would result in better functional outcomes and higher patient satisfaction [17,20-22,30]. This technique was simple and more reliable than relying on poor bony anatomical landmarks, which can be difficult to measure accurately during the procedure and have different anatomical variations, or on tensioning devices because they fail to produce the physiological varus laxity during knee flexion and instead aim for equal tension throughout the full range of motion [23,24].

Spacer blocks are commonly used in TKA surgeries. Gungor., *et al*. [25]. evaluated the efficacy of spacer blocks in determining joint-line position during revision TKA and found that the spacer block tool is a useful and inexpensive tool for less experienced and low-volume revision TKA surgeons. Stiehl., *et al.* [26] compared the precision of both the computer-navigated system with that of spacer blocks on eight cadaveric specimens and detected a difference of only 1 mm. Jhurani., *et al.* [27] used computer-assisted navigation and spacer blocks to evaluate 50 patients with moderate varus deformity followed by implant trials and noticed a significant 6.2° difference (p = 0.001) in deformity in the sagittal plane throughout extension between spacers and trials, indicating that the knee achieves more extension with spacer blocks than with trials because of the absence of a posterior offset, in contrast to the native femoral condyle. However, no difference in soft-tissue balance or coronal-plane correction values was seen between spacer blocks and trials in both extension and 90° flexion. Frédéric., *et al*. [28] conducted a 3-year retrospective analysis on 114 patients, utilizing a modified spacer block and a gap-balancing approach. He reported significant improvement in all functional outcome scores. At the most recent follow-up, 96% of knees were well-balanced. Yanahu., *et al*. [29] compared the functional outcomes of 114 patients in whom 61 procedures were performed using gap-balancing techniques with the assistance of a modified spacer block, and 63 procedures were performed using the measured resection technique. Similar functional outcomes were found at 3 years.

There were some study limitations that should be considered. First, there was no control group to compare the outcomes and other variables. Second, 18 months is a brief period of follow-up for patients with total knee replacement. Additionally, there were no precise mechanical quantitative indicators for the use of plastic spacers; instead, they relied mainly on the surgeon's subjective perception, which can be easily developed to obtain satisfactory outcomes. Finally, although the patients in this trial were followed for a minimum of 6 months, a higher survival rate can be observed over a longer period.

Conclusion

This study showed that the use of a hybrid balancing technique combined with a modified spacer block provided stable knees with great functional outcomes. However, higher quality randomized controlled studies are required for a better evaluation of this method.

Conflict of Interest

Authors Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Bibliography

1. Sierra RJ and Rachala SR. "Unicompartmental, bicompartmental, or tricompartmental arthritis of the knee: algorithm for surgical management". In: Scott WN, edition. Insall and Scott Surgery of the Knee. 6th edition. New York: Elsevier (2017): 1405-1409.
2. Sugita T., *et al*. "Quality of life after bilateral total knee arthroplasty determined by a 3-year longitudinal evaluation using the Japanese knee osteoarthritis measure". *Journal of Orthopaedic Science* 20 (2015): 137-142.
3. Shatrov J and Parker D. "Computer and robotic - assisted total knee arthroplasty: a review of outcomes". *Journal of Experimental Orthopaedics* 7 (2020): 70.
4. Zak SG., *et al*. "The use of navigation or robotic-assisted technology in total knee arthroplasty does not reduce postoperative pain". *Journal of Knee Surgery* (2021).
5. Kim YH., *et al*. "Does robotic-assisted TKA result in better outcome scores or long-term survivorship than conventional TKA? A randomized, controlled trial". *Clinical Orthopaedics and Related Research* 478 (2020): 266-275.
6. AOA national joint replacement registry.
7. Kurtz S., *et al*. "Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002". *The Journal of Bone and Joint Surgery. American Volume* 87 (2005): 1487-1497.
8. Kurtz S., *et al*. "Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030". *The Journal of Bone and Joint Surgery. American Volume* 89 (2017): 780-785.
9. Sheng PY., *et al*. "Revision total knee arthroplasty: 1990 through 2002. A review of the Finnish arthroplasty registry". *The Journal of Bone and Joint Surgery. American Volume* 88 (2006): 1425-1430.
10. Babazadeh S., *et al*. "Gap balancing sacrifices joint-line maintenance to improve gap symmetry: a randomized controlled trial comparing gap balancing and measured resection". *The Journal of Arthroplasty* 29 (2014): 950-954.
11. Daines BK and Dennis DA. "Gap balancing vs. measured resection technique in total knee arthroplasty". *Clinics in Orthopedic Surgery* 6 (2014): 1-8.
12. Luyckx T., *et al*. "Is adapted measured resection superior to gap-balancing in determining femoral component rotation in total knee replacement?" *Journal of Bone and Joint Surgery: British Volume* 94 (2012): 1271-1276.
13. Luyckx T., *et al*. "Is adapted measured resection superior to gap-balancing in determining femoral component rotation in total knee replacement?" *Journal of Bone and Joint Surgery: British Volume* 94 (2012): 1271-1276.
14. Mercuri JJ., *et al*. "Gap balancing, measured resection, and kinematic alignment: How, When, and Why?" *JBJS Reviews* 7 (2019): e2.
15. Berger RA., *et al*. "Determining the rotational alignment of the femoral component in total knee arthroplasty using the epicondylar axis". *Clinical Orthopaedics and Related Research* 286 (1993): 40-47.

16. Poilvache PL., *et al*. "Rotational landmarks and sizing of the distal femur in total knee arthroplasty". *Clinical Orthopaedics and Related Research* 331 (1996): 35-46.

17. Mantas JP., *et al*. "Implications of reference axes used for rotational alignment of the femoral component in primary and revision knee arthroplasty". *The Journal of Arthroplasty* 7 (1992): 531-535.

18. Vail TP and Lang JE. "Surgical techniques and instrumentation in total knee arthroplasty". In: Scott WN, ed. Insall and Scott Surgery of the Knee. 6th edition. New York: Elsevier (2017): 1665-1721.

19. Nam D., *et al*. "Patient dissatisfaction following total knee replacement: a growing concern?" *Bone Joint Journal Supplement A* (2014): 96-100.

20. Kamenaga T., *et al*. "The influence of postoperative knee stability on patient satisfaction in cruciate-retaining total knee arthroplasty". *The Journal of Arthroplasty* 33 (2018): 2475-2479.

21. Aunan E., *et al*. "Intraoperative ligament laxity influences functional outcome 1 year after total knee arthroplasty". *Knee Surgery, Sports Traumatology, Arthroscopy* 23 (2015): 1684-1692.

22. Unitt L., *et al*. "Balancer Study Group. Short-term outcome in total knee replacement after soft-tissue release and balancing". *Journal of Bone and Joint Surgery: British Volume* 90 (2008): 159-165.

23. Roth JD., *et al*. "Native knee laxities at 0°, 45°, and 90° of flexion and their relationship to the goal of the gap-balancing alignment method of total knee arthroplasty". *The Journal of Bone and Joint Surgery. American Volume* 97 (2015): 1678-1684.

24. Tokuhara Y., *et al*. "The flexion gap in normal knees. An MRI study". *Journal of Bone and Joint Surgery: British Volume* 86 (2004): 1133-1136.

25. Gungor HR and Ok N. "Use of a spacer block tool for assessment of joint line position during revision total knee arthroplasty". *Journal of Knee Surgery* (2021).

26. Stiehl JB and Heck DA. "How precise is computer-navigated gap assessment in TKA?" *Clinical Orthopaedics and Related Research* 473 (2015): 115-118.

27. Jhurani A., *et al*. "Do spacer blocks accurately estimate deformity correction and gap balance in total knee arthroplasty? A prospective study with computer navigation". *Knee* 27 (2020): 214-220.

28. Lavoie F. "Spacer-based gap balancing in total knee arthroplasty: clinical success with a reproducible technique". *Journal of Knee Surgery* 30 (2017): 798-806.

29. Hu Y., *et al*. "Spacer-based gap balancing is useful in total knee arthroplasty: a 3-year follow-up of a retrospective study". *Journal of Orthopaedic Surgery and Research* 16 (2021): 633.

30. Azukizawa M., *et al*. "Intraoperative medial joint laxity in flexion decreases patient satisfaction after total knee arthroplasty". *Archives of Orthopaedic and Trauma Surgery* 138 (2018): 1143-1150.