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The Effect of Valgus Deformity Degree of Knee Osteoarthritis Patients on Tibiofemoral Angle Mechanical Output and Knee Society Score After Total Knee Arthroplasty Non-Constrained at Prof. Dr. I.G.N.G Ngoerah Hospital

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ABSTRACT

Background: Osteoarthritis (OA) is a progressive musculoskeletal problem causing a loss of articular cartilage and damage to cellular and biomechanical components. In Indonesia, the prevalence of OA is 36.5 million people, with 40% over 70 years old and 80% with limited movement. Malalignment in the knee joint, found in almost 10% of patients undergoing total knee arthroplasty (TKA) surgery, is a challenge for orthopedic surgeons. Factors such as body weight, high BMI, work history, malalignment, and synovitis are associated with the development of knee OA. Total Knee Arthroplasty (TKA) is a surgical procedure to overcome OA problems in the knee joint, but deformities affect the success of TKA surgery. Researchers aim to determine if there is an association between valgus deformity in knee OA patients and tibiofemoral angle correction and Knee Society Score 12 weeks after TKA.

Methods: The study involved 42 patients with primary knee osteoarthritis and valgus deformity who underwent primary Total Knee Replacement (TKR) at Prof. Dr. Ngoerah Hospital. The study included patients with grade III-IV Kellgren-Lawrence knee osteoarthritis, underwent primary TKA, and had lower extremity scans before and 12 weeks postoperatively. Functional and clinical outcomes were measured using mechanical tibiofemoral angle and Knee Severity Score.

Results: The study involved 21 female patients with OA Ranawat 2 and a 7:1 ratio of male and female participants. The most common OA was in the right knee. After TKR, there was no significant difference in MTFA and KSS scores between patients. However, after 12 weeks, the average MTFA score decreased to 8.57, with a significant change before and after the surgery.

Keywords: Osteoarthritis, total knee arthroplasty (TKA), Kellgren-Lawrence.

INTRODUCTION

Osteoarthritis (OA) is a progressive musculoskeletal problem that is most commonly found in the community. Loss of articular cartilage, the presence of damage from cellular and biomechanical components are considered the main causes

of OA. The treatment of knee OA patients with valgus deformity performed by TKA with *non-constraint* implants is a challenge for orthopedic surgeons because there are often poor outcomes in postoperative patients including tibiofemoral instability, recurrent valgus deformity, joint scope deficit, *patellar maltracking*, and peroneal nerve injury. The prevalence rate of osteoarthritis in Indonesia reaches 36.5 million people and 40% comes from the population over the age of 70 years who suffer from OA and reaches 80% who have limited movement in various levels from mild to severe. (Sonjaya et al., 2015) Along with the increase in life expectancy, according to WHO in 2025 the elderly population in Indonesia will increase by 414% compared to 1990. (Indonesian Rheumatology Association, 2014) Osteoarthritis of the knee joint with *malalignment* provides difficulties for operators when going to perform total *knee arthroplasty (TKA*) surgery and this deformity is found in almost 10% of the total patients who undergo TKA surgery. (Utomo et al., 2018).

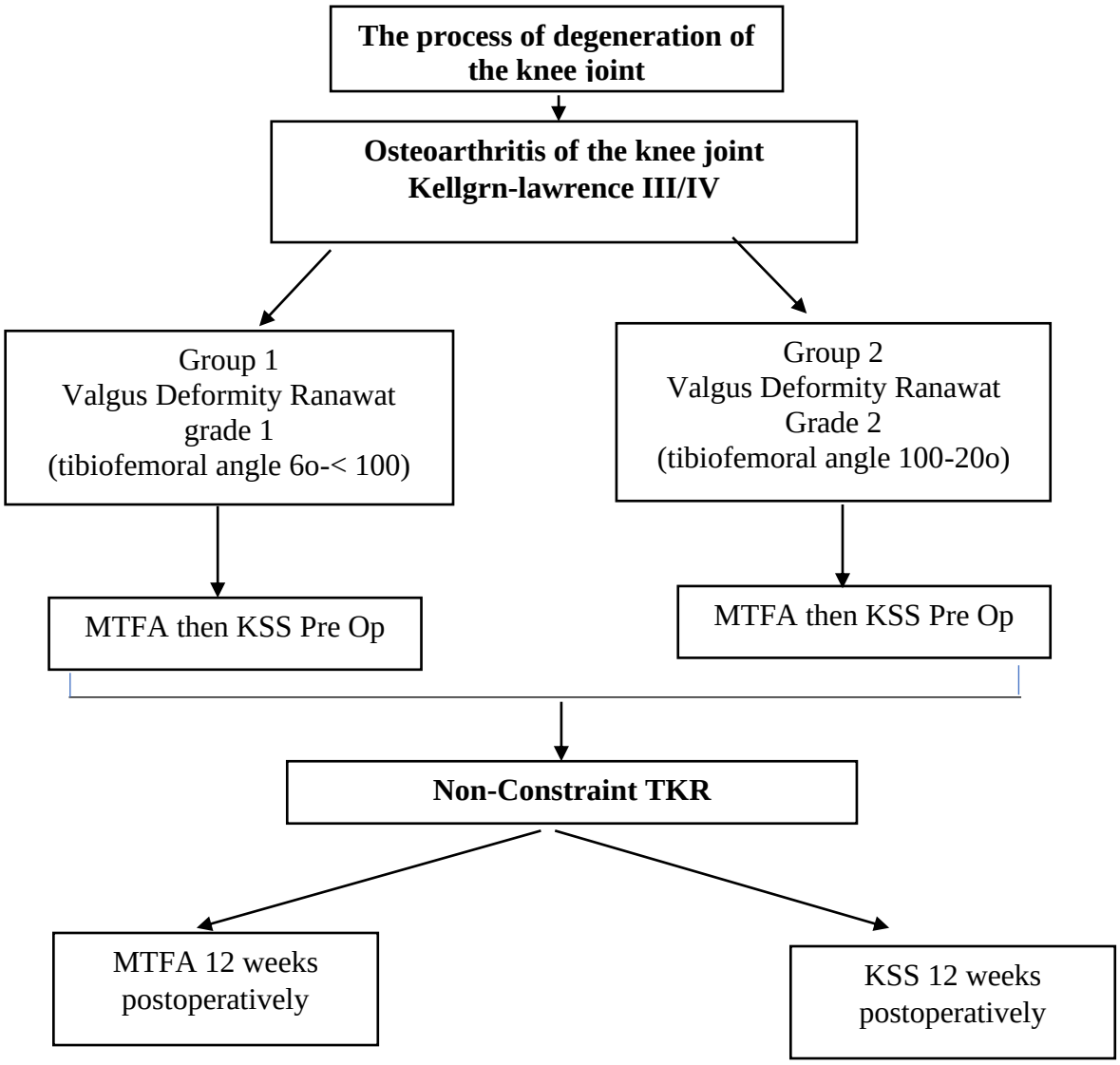
Valgus deformity in osteoarthritis of the knee is an ongoing process initiated by bone tissue remodeling and soft tissue contraction/lengthening. Changes in bone tissue consist of cartilage erosion, lateral condyle hypoplasia, and metaphysical remodeling of the femur and tibial plateau. Soft tissue changes are characterized by contractures of lateral structures such as lateral collateral ligaments (LCL), posterolateral capsule (PLC), popliteus tendon (POP), hamstring tendons, lateral gastrocnemius (LHG) and iliotibial muscles (ITB). Body weight, high body mass index, work history, malalignment and synovitis have been consistently reported as factors associated with the development of knee OA. Malalignment of the knee joint was found to be an independent risk factor for the development of knee OA. Malalignment of the varus increases the risk of progression of medial side osteoarthritis (OA). A comparison of varus versus valgus malalignment compared to normal *alignment* shows that *varus malalignment has better disease progression compared to* valgus *malalignment*.(Heidari, 2011).

Total Knee Arthroplasty (TKA) is a surgical procedure performed to overcome OA problems in the knee joint that cannot be treated conservatively. Deformities that occur in the knee with OA affect the success of TKA surgery so correction of the deformity to restore normal *alignment* is still a challenge. Because the outcome of TKA is influenced by various factors that must be considered, the researchers intended to determine whether there was an association between the degree of valgus deformity in knee OA patients and the degree of tibiofemoral angle correction, *Knee Society Score* (KSS) 12 weeks after Total *Knee Arthroplasty* (TKA). This research is expected to be useful in daily practice and be a source of information and education for patients regarding the prognosis of *Total Knee Arthroplasty surgery* in OA of the knee joint based on the type of deformity.

MATERIALS & METHODS

The study was approved by the institutional ethics review board of our institution. From March 2023 to December 2023, a total of 42 patients diagnosed with primary osteoarthritis with valgus deformity who underwent primary Total Knee Replacement (TKR) from January 2021 to April 2023 in Prof. Dr. Ngoerah Hospital were included in this study. The primary knee osteoarthritis diagnosis was obtained with long leg x-ray or scannogram. The TKR implant used in this study was non-constrained implant. The inclusion criteria were patients diagnosed with grade III-IV *Kellgren-Lawrence* knee osteoarthritis and valgus deformity, patients underwent primary TKA, and the availability of lower extremity *scanograms* before and 12 weeks postoperatively. Patients who underwent TKR revision, patients without x-ray or scannogram data,

and patients who rejected to be included in this study were excluded. The functional and clinical outcomes were measured using mechanical tibiofemoral angle 12 weeks post-operatively and Knee Severity Score (KSS).



STATISTICAL ANALYSIS All statistical analyses were performed using SPSS Statistics version 24 (IBM Corp., Armonk, NY, USA). The variables were analysed using *Wilcoxon signed rank test*. The level of significance was set at $P < 0.05$ for all statistical analyses.

RESULT

Patients' characteristics are shown in table 1. Study participants with an average age of 56.08 ± 3.42 years with a dominance of female participants. The ratio of female and male participants was 7:1, consisting of 21 female participants (87.5%) and 3 male participants (12.5%). In OA Ranawat 2 the average age was older (62.75 ± 2.1 years), compared to Ranwat 1 (56.08 ± 3.42 years). The location of the most OA was the right knee (66.7%).

Table 1. Patient characteristics

	Ranawat 1 n (%)	Ranawat 2 n (%)	Total n (%)
Gender			
Man	2 (16,7)	1 (8,3)	3 (12,5)
Woman	10 (83,3)	11 (91,7)	21 (87,5)
Usia (mean ± SD)	56.08 ± 3.42	62.75 ± 2.1	56.08 ± 3.42
OA Location			
Right Knee	5 (41,7)	11 (91,7)	16 (66,7)
Left Knee	7 (58,3)	1 (8,3)	8 (33,3)

Table 2. Differences In Average *Mechanical Tibiofemoral Angle* (MTFA) Scores

Average Score	Derajat deformed OA light	N	*Mean Rank*	*Sum of Ranks*	*p-value*
MTFA pasca TKA	Ranawat degree 1	12	12,17	146,00	0,817
	Ranawat degree 2	12	12,83	154,00	

There was no significant difference in the average output of MTFA scores between patients with degrees of deformity of OA valgus Ranawat degree 1 and Ranawat degree 2 after TKR (p = 0.817) as shown in table 2

Table 3. Differences In the Average *Knee Society Score* (KSS) Scores

Average Score	Derajat deformed OA light	N	*Mean Rank*	*Sum of Ranks*	*p-value*
KSS pasca TKA	Ranawat degree 1	12	10,46	125,50	0,130
	Ranawat degree 2	12	14,54	174,50	

Based on statistical tests, there was no significant difference in the average output of KSS scores between patients with degrees of deformity of OA valgus Ranawat degree 1 and Ranawat degree 2 after TKR (p = 0.130).

Table 4. Changes in average MTFA scores before and after TKR

Score		Score Min	Score Max	Mean skor	Delta mean	SD	*Test statistic*	*p-value*
MTFA	Before TKA	2,76	19,89	11,88	8,57	6,17	6	0,000
	After TKA	1,02	11,59	3,23		2,95		

Based on the calculation of MTFA score data before and 12 weeks after TKR surgery, there was a decrease in the average MTFA score after TKR of 8.57 compared to before TKR. Based on statistical tests, there was a significant change in the average MTFA score before and after the TKR (p = 0.000).

Table 5. Changes in average KSS scores before and after TKR

Score		Score Min	Score Max	Mean skor	Delta mean	SD	*Test statistic*	*p-value*
KSS	Before TKA	30	60	43,8	28,3	10,45	276	0,000
	After TKA	55	80	72,1		7,93		

Based on the calculation of KSS score data before and 12 weeks after TKR surgery, there was an increase in KSS score after TKR by 28.3 compared to before TKR. There was a significant change in the average KSS score before and after the TKR. (p = 0.000).

DISCUSSION

A balanced proportion was obtained between the degree of valgus deformity of Ranawat degree 1 and Ranawat degree 2. The proportion of knee OA with valgus deformity is reported to be less than with varus deformity. This is because the knee joint has a structure called the meniscus, which functions as a shock absorber and load spreader. It is known that the medial meniscus absorbs loads better than the lateral meniscus. (Zhang et al., 2021) *Medial soft tissue laxity* is a condition in which the ligament and medial tendon of the knee are stretched or torn. This condition can cause knee instability and increase the

risk of injury. According to the Study of Briem et al. (2017).

Assessment of soft tissue laxity in patients with valgus deformity in osteoarthritis (OA) involves several methods, including measuring the angle of valgus using a goniometer, examining varus-valgus stress tests, and examination with imaging tools such as ultrasound or MRI. The goniometer method involves measuring the angle of the valgus at the knee joint to assess the degree of valgus deformity and the tenderness of the medial soft tissue. Physical examination with a varus-valgus stress test provides a picture of the joint's response to pressure, while imaging devices provide detailed information about soft tissue structures and ligaments. Subjective evaluation and the use of subjective scales or numerical values are also involved, allowing the patient to convey their perception of tenderness or laxity of the joints . (Briem et al., 2007)

In valgus deformity, the lateral meniscus may be subjected to extra pressure and overload, which can cause further damage . Most patients in this study were female (87.5%) with an average age of 56.08 ± SD 3.42. Naturally, estrogen has an important role in regulating the inflammatory response in the body. As the dominant female sex hormone, estrogen has been identified as having strong anti-inflammatory properties. In the context of osteoarthritis, studies have shown that estrogen has the potential to reduce inflammation in affected joints. Estrogen is believed to affect the production of inflammatory mediators and enzymes involved in joint damage associated with osteoarthritis. Nonetheless, the exact mechanism of how estrogen controls the inflammatory response in the context of osteoarthritis is still not fully understood. However, preliminary evidence suggests that the presence of estrogen in the body can have a protective effect on the development and progression of osteoarthritis through its anti-inflammatory properties. Therefore, a deeper understanding of this relationship could provide new insights in the development of more effective treatment strategies for managing osteoarthritis, especially in populations prone to declining estrogen levels, such as post-menopausal women. This can be caused because in women aged 50 years there is a decrease in joint synovial fluid production whose function is to reduce friction between knee joints, causing the risk of knee OA. Several studies reported that the location of OA mostly occurred in the right knee (66.7%) where the same was found in this study. (Cho et al., 2016) (Di Nicola, 2020; Mathiessen & Conaghan , 2017; Sanchez -Lopez and to the. , 2022)

The results of this study showed no significant difference in the average output of MTFA scores between patients with degree deformity OA valgus Ranawat degree 1 and Ranawat degree 2 after *non-constrained* TKA ($p = 0.817$). Therefore, the use of *non-constraint* TKA can be a treatment option in patients with OA valgus. TKA *constraint* is a technique in which the implicated knee prosthesis has limitations in the movement of the larger knee joint. In this case, the prosthesis used is stronger and more stable. TKA *constraint* is better applied to patients with poor knee joint stability before surgery. TKA *constraints* are also used in patients with severe ligament damage. The disadvantage of TKA *constraint* is that the patient's recovery after surgery will take longer. In addition, tighter movement restrictions are also needed in daily activities. Non-constraint TKA has greater flexibility in patient movement, so patients are more free to move. Non-constraint TKA *is* better applied to patients who have good joint stability before the surgical procedure is performed, as well as relatively good ligament condition. The application of *non-constraint* TKA allows a shorter time for recovery. (Castellarin and to the., 2023; Marya & Singh, 2021; Morgan-Jones & Graichen, 2021)

From the results of this study, it was found that there were differences in MTFA before and after surgery, both Ranawat 1 and 2 and

there was a relationship between MTFA and the degree of Ranawat. This is consistent with other studies showing that degrees of correction are significantly correlated ($R = 0.95$, $p < 0.05$), even though the knee and ankle joint lines are corrected to a neutral orientation. This study then tried to determine the limit value of 16.5° [AUC 0.912 (0.85–0.975 95% CI), sensitivity = 0.8, specificity = 0.895]. In addition, the study found that symptoms would be aggravating according to MTFA values [OR 34.0 (9.10 –127.02 95% CI)]. The study by Gurusu et al analyzed retrospectively in 80 patients who all had preoperative valgus deformities > 10°. Nineteen patients complained of increased ankle pain after TKA. Thirteen of these 19 patients had a preoperative MTFA of > 15°, matching previously reported cut-off values for valgus osteoarthritis. Study by Kim et al. on 55 patients who had valgus osteoarthritis of the knee and underwent TKA. In 12.3% of cases, patients experienced worsening ankle symptoms after surgery. Therefore, correction of valgus deformity with a high degree has the potential to cause disorders of the ankle joint (Kim et al., 2018)

In contrast, a study by Kim et al. found that patients with valgus knee osteoarthritis who underwent TKA and experienced increased postoperative ankle pain compared to patients who did not complain of ankle pain. This may be due to ankle symptoms already present before surgery, but masked by pain in the knee joint and limited physical activity. (Kim et al., 2018)

There are several reasons why non-constraint TKA can still be applied to valgus deformity. In mild valgus deformity, both the bones and soft tissues of the knee still maintain enough strength to bear weight, so non-restriction TKA can be used to restore knee function without restricting movement. For young patients, who have a longer life expectancy, the selection of TKA that provides optimal results in the long term is crucial. (Rossi et al., 2014)

The results of this study showed no significant difference in average KSS output between patients with degree 1st degree of OA valgus deformity Ranawat 1st degree and 2nd degree Ranawat after non-constraint TKA ($p = 0.130$). Some studies reported that grade 2 Ranawat valgus OA showed better clinical and radiological outcomes when performed *with TKA constraint, but the results of this study showed that patients with Ranawat 1 and Ranawat 2 deformity with* non-constraint TKA both showed equally good outcomes after 12 weeks of action. The surgical engineering facilities available at RSUP Prof. Dr. IGNG Ngoerah are (Castellarin et al., 2023; Lv et al., 2022) *non-constraint techniques*. Based on the results of this study, non-constrain TKA surgery techniques for the management of OA patients with valgus deformity at RSUP Prof. Dr. IGNG. Ngoerah can still be done and provides a good output. Long-term monitoring will also be very useful for patients after surgery to ascertain whether the prosthesis is functioning properly and whether or not there is a possibility of postoperative complications.

Furthermore, this is consistent with other studies that have found that mild valgus can achieve better or similar clinical outcomes. Studies by Vanlommel et al. show that KSS scores increased after TKA where the mild valgus group performed significantly better in total KSS (169.5) compared to the neutral valgus group (159.0; $P = 0.02$) and heavy valgus group (152.9; $P = 0.01$). In addition, studies by Slevin et al. showed that valgus levels after TKA are the most relevant factor for the incidence of maltracking patella . At the same time, another study showed that the average modified Knee Society clinical score increased from 30 points before surgery to 93 points postoperatively, and the average functional score increased from 34 to 81 points postoperatively. The average range of motion is 110° both before surgery and postoperatively. The average coronal

alignment was corrected from 15 degrees valgus before surgery to 5 degrees valgus postoperatively. (Vanlommel and to the, 2013) (Slevin et al., 2017)

However, a different point was shown by another study showing that no significant differences were found between the matched varus and valgus cohorts across all WOMAC subdomain scores except for slightly worse stiffness at 1 year in patients with valgus deformity (WOMAC stiffness, varus 75.1 vs 70.1 valgus; P = 0.049). In addition, there was no significant difference in postoperative varus/valgus alignment between the two groups before and after (P = 0.092. The study did use WOMAC in its parameters. (Kahlenberg et al., 2018)

In patients with valgus deformity, the balance of soft tissues is often disturbed, can result in instability in the knee, and increases the risk of injury. In the implementation of nonconstrained TKA operations, it is very important to restore the balance of soft tissues to optimal. A variety of techniques can be used to achieve this, including bone cutting to correct valgus deformity, ligament cutting to reduce knee instability, and tendon removal to strengthen the muscles around the knee. A study published in The Journal of Arthroplasty in 2018 highlighted the significant influence of soft tissue balance during surgery on surgical outcomes on nonconstraint valgus deformity. In this study, involving 100 patients undergoing nonconstraint TKA with valgus deformity, it was found that the group that received soft tissue balance correction during surgery showed better outcomes, including lower levels of knee instability, lower pain levels, and higher levels of satisfaction compared to the group that did not get soft tissue balance correction (Clark et al., 2018)

The results of this study showed a decrease in the average MTFA score after TKA by 8.57 compared to before TKA. The decrease in MTFA scores in OA patients after surgery showed a positive response to therapeutic outcomes. An MTFA score of <6 indicates a better degree of correction. The mechanical tibiofemoral axis (MTFA) is considered physiologically aligned if the axis is in the range of ± 3°. The study by Graef et al. also found that there was a change in MTFA scores from 5.0 (2.0-14.0) to 20.0 (17.0-23.0) degrees. This change is also statistically significant p<0.001. There was a significant change in the average MTFA score before and after TKA (p = 0.000) in this study showed the success of operative action in patients with valgus deformity OA performed by TKA at RSUP Prof. Dr. IGNG. Ngoerah. (Huang et al., 2012; Zahn et al., 2020) (Graef et al., 2022b)

However, the study by Chang C. et al. found that there was no difference in mTFA scores before and after TKA in osteoarthritis patients (p>0.1). This is because this study compares using two different anatomical points. TFA anatomical definitions can affect the accuracy of MTFA estimations. In this study, researchers defined two anatomical TFAs, namely anatomical TFA1 and anatomical TFA2, using different femoral and tibial bisection points, namely at 10 cm and 15 cm from the knee joints respectively. Researchers found that anatomical TFA2 had a better correlation with mechanical TFA in all three studies. (Chang et al., 2010)

Nonconstraint and constraint Total Knee Arthroplasty (TKA) are two variants of TKA that have differences in design and working principle. Nonconstraint TKA has no components that restrict knee movement, so the femoral and tibial components can move independently, allowing natural knee movement. In contrast, TKA constraints have components that limit knee movement with additional elements such as tibial post or cam-and-post mechanisms, which help maintain knee stability, especially in patients with knee deformity or instability. TKA is commonly used to treat osteoarthritis (OA), a condition that damages joint cartilage and causes pain, swelling, and stiffness in the joints.

Nonconstraint TKAs tend to be suitable for patients with mild to moderate knee OA, who have fairly strong bones and soft tissues. In contrast, TKA constraint is more appropriate for patients with more severe knee OA or with symptoms of knee deformity and instability, where additional components can help maintain stability and reduce the risk of dislocation. (Anderst & Fu, 2018) *Soft tissue balancing* is an essential aspect of bone surgery procedures that focus on adjusting the soft tissues around the joints to achieve optimal balance. In the context of joint surgery such as knee joint replacement, these steps are important to ensure soft tissues, such as muscles, ligaments, and capsules, are in the right position. The process begins with a thorough evaluation before surgery to plan an appropriate adjustment strategy during the procedure. The doctor will make soft tissue adjustments, measure the pressure generated, and monitor the stability of the joint to ensure the ideal balance. With the right balance, patients have a greater chance of successful recovery and better joint function postoperatively, as well as reduced risk of long-term complications.

The results of this study also showed an increase in KSS score after TKA by 28.3 compared to before TKA. Another study conducted by Goh et al showed an increase in KSS scores after TKA was performed, which means there is an improvement in the patient's condition after surgery. Increased KSS scores in OA patients after surgery showed a positive response to therapeutic outcomes, where patients experienced clinical progress in knee conditions such as reduced pain, decreased knee joint motion by flexion and extension, knee joint stability, and in terms of functions such as walking, climbing stairs, and dependence on using walking aids. There was a significant change in the average KSS score before and after TKA ($p = 0.000$) in this study showed the success of operative action in patients with valgus deformity OA performed by TKA at RSUP Prof. Dr. IGNG. Ngoerah. (Goh et al., 2021) (Zahn et al., 2020)

However, the study by West J. et al. found no significant changes in KSS scores before and after TKA. This study obtained KSS scores before TKA of 49.7 ± 6.04 and after TKA of 79.5 ± 8.56 in the third month and 80.8 ± 6.48 after one year. This study explains that these results were obtained because the type of study was a cohort study with a small number of samples so further research is needed. In addition, a study by Bian T. et al. showed that KSS scores were influenced by the patient's psychological condition. Patients with major depression will experience a smaller increase in KSS. This suggests that this score focuses on the patient's subjective feelings and perceptions of pain related to psychological status. (West et al., 2019) (Bian et al., 2021)

Nonconstrained and *constrained* Total Knee Arthroplasty (TKA) have advantages and disadvantages that must be considered in the selection of the type of surgery. Nonconstrained TKAs provide more natural knee movements and have a lower risk of dislocation, as well as record higher levels of patient satisfaction. However, not all patients are suitable for nonconstraint TKA, especially for those with severe knee deformity, knee instability, or ligament deficiency. In addition, *nonconstrained* TKA may increase the risk of knee instability and dislocation, and may be less suitable for highly active patients. On the other hand, *constrained TKA* helps maintain knee stability and reduces the risk of instability, making it a good choice for highly active patients. However, TKA constraints had less natural knee movements, increased risk of dislocation, and recorded lower levels of patient satisfaction. In addition, revision of constraint TKA is usually more difficult to do compared to nonconstraint TKA. Therefore, the selection of the type of TKA must be based on the needs and individual clinical characteristics of the patient . (Young et al., 2012)

This study is by far the first study to look at the relationship of valgus deformity with MTFA and KSS outcomes where the deformity is distributed by degree. Until now there are still no studies that divide by degree from valgus.

Postoperative patients with total knee arthroplasty have various expectations and expectations regarding function and the recovery process. In general, patients' expectations after surgery include improvements in mobility, reducing or eliminating pain associated with advanced osteoarthritis, as well as allowing them to return to daily activities comfortably. Patients also hope that surgery can improve their overall quality of life, both in terms of physical and psychological aspects. They want an increased ability to walk, sit, and stand without annoying pain. In addition, patients may also expect to be able to return to activities they enjoyed before their knee condition worsened, such as exercising lightly or participating in social activities. However, it is important to remember that these expectations can vary based on the patient's preoperative health condition, the severity of osteoarthritis, and other factors that affect the post-operative recovery process. Good communication between doctors and patients is essential to understanding realistic expectations and providing appropriate support during the recovery process.

CONCLUSION

Based on this study, non-constrained TKR surgery showed the same good clinical and radiological outcomes, in all knee osteoarthritis patients with grade 1 and 2 Ranawat valgus deformity.

Declaration by Authors

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