COMPARISON OF FUNCTIONAL OUTCOME BETWEEN NEUTRAL WITH RESIDUAL MILD CORONAL ALIGNMENT POST PRIMARY TOTAL KNEE ARTHROPLASTY: THREE YEARS FOLLOW-UP IN MAKASSAR, SOUTH SULAWESI

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Abstract

Introduction: Total Knee Arthroplasty (TKA) is an orthopedic procedure that replaces a damaged knee joint with an artificial prosthesis to reduce pain and restore knee function. Neutral coronal alignment post-TKA is often considered a standard of success, although some studies suggest that mild residual coronal alignment might provide better clinical outcomes. This study aims to compare the clinical functional outcomes between neutral coronal alignment and mild residual coronal alignment in patients post-TKA after a three-year follow-up in Makassar, South Sulawesi.

Method: This research is a prospective observational study conducted at RSUP Wahidin Sudirohusodo, Makassar, involving patients with grade III or IV knee osteoarthritis who underwent TKA from January to December 2020. Samples were taken through consecutive sampling and included patients over 40 years old with either neutral coronal alignment or mild residual coronal alignment post-surgery. Clinical functional outcomes were measured using The Knee Society Score: Short Form and The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score list.

Results: This study utilized the Short Form Knee Society Score (SF-KSS) to evaluate total knee arthroplasty, along with The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score list, where a p-value > 0.05 was found, indicating no significant difference.

Conclusion: There were no notable differences in clinical functional outcomes between the neutral and mild residual mechanical alignment groups. This can serve as a reference in performing total knee arthroplasty, allowing surgeons to preserve more tissue structures and bone to achieve mild residual alignment rather than performing aggressive releases to achieve neutral alignment.

Introduction

Total Knee Arthroplasty (TKA) is one of the most common and successful procedures performed in modern orthopedics, which involves replacing the damaged knee joint with prosthesis to reduce severe pain and restore knee function.[1-4] To correct the knee valgus/varus during TKA, coronal alignment is used based on several axes, the first one being the lower extremity mechanical axis which is measured from the central femoral head to the central talar dome on standing long-leg anteroposterior x-ray. The other axis used for the alignment is the anatomical axis of the femur, which is a line running along the femoral intramedullary canal, similar to the tibia. The angle created from the anatomical and mechanical axis is around 6°, which varies depending on the person's height; while for the tibia the angle is 0°. Postoperative neutral alignment has been used as a benchmark for the success of TKA surgery. Several studies indicate that a more than 3° deviation will result in lower functional scores and reduced long-term implant durability. The reduced durability of the implant is based on the principle of uneven load distribution, which leads to increased shear stress and results in wear and aseptic loosening, particularly in the prosthesis polyethylene component. Nevertheless, the relationship between postoperative alignment and patient satisfaction has always been a controversial issue among researchers. Some researchers suggest leaving the patient's "natural" alignment gives a higher patient satisfaction. Meanwhile, the current popular paradigm is to restore alignment to a neutral category according to lower limb biomechanics.

The study on the degree of alignment correction suitable for the Indonesian population has not been conducted, making it the basis for this research idea. Based on the previously stated, the question of whether a better functional clinical comparison between neutral coronal alignment and mild residual coronal alignment after 3 years of follow-up exists or not. Besides the main question regarding the clinical comparison, this study also aims to find the optimal alignment correction to provide the best clinical functional results for the studied population, determining the reproducibility of studies that have been conducted at other centers regarding the South Sulawesi population, as well as evaluating the postoperative patient's satisfaction using residual alignment compared to neutral alignment.

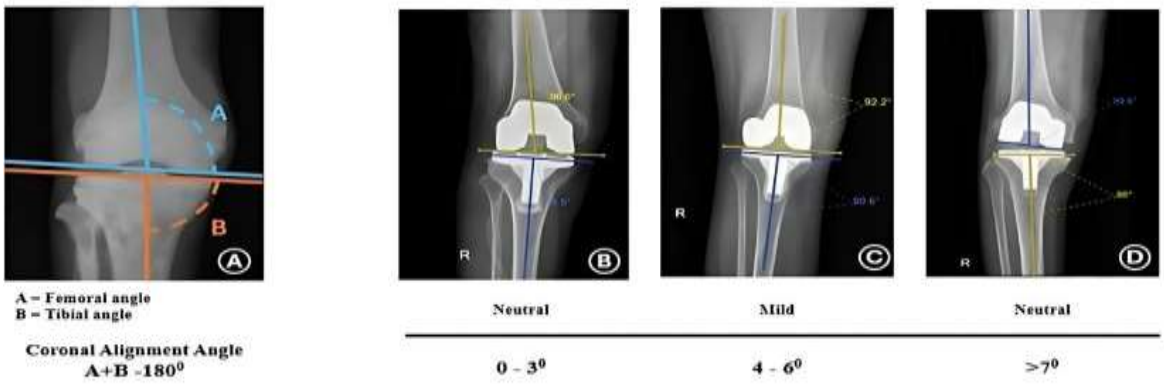

Figure 1. Method of calculation of coronal alignment angle pre- and post-operatively. The angle formed when the line that forms the femoral shaft axis is extended through the distal femur to form an angle between the femoral shaft axis and the tibial shaft axis. (A) Pre-operatively knee alignment, (B-D) post-operatively knee alignment (B) normal varus/valgus alignment, 0-3^o of varus/valgus alignment, (C) mild varus/valgus alignment, 3-6^o of varus/valgus alignment, (D) severe varus/valgus alignment, >6^o of varus/valgus alignment

Materials and Methods

The research is the retrospective study and was conducted at Wahidin Sudirohusodo Hospital, Department of Orthopedics and Traumatology, Faculty of Medicine, Hasanuddin University, Makassar. The research was conducted in January 2023 through December 2023. The population included in this study is patients diagnosed with grade III or IV knee osteoarthritis who underwent Total Knee Arthroplasty at RSUP Wahidin Sudirohusodo, Makassar. Samples were taken from knee osteoarthritis patients who received TKA surgical treatment from January 2020 to December 2020, and were selected based on inclusion and exclusion criteria. Sampling is done by collecting the patient's medical data as secondary data and conducting interviews and filling out questionnaires as primary data, while the technique used for data collection is consecutive sampling where all the patients within the timeframe are taken and examined. Inclusion criteria used for sampling were as follows: 1) patient over 40 years old with grade III or IV osteoarthritis, 2) patient who had undergone Total Knee Arthroplasty, unilateral or bilateral, for more than 3 years, 3) patient with neutral coronal alignment and mild residual coronal alignment, 4) patient consented to participate in the research. Meanwhile, the exclusion criteria for the patients were: 1) those who were lost in the follow-up, 2) patients with neurologic deficits that affected their walking pattern, 3) patients with history of infection, mal-alignment due to knee joint fracture, or autoimmune diseases involving the knee joint, and 4) patients who underwent bilateral TKA in one day (one-stage operation).

Instruments used in this research were the patient's medical record coupled with The New Knee Society Score: Short Form Functional Outcome Assessment questionnaire, digital goniometry and Osteoarthritis Index (WOMAC) Score List to assess the patient's postoperative satisfaction, clinical function and the postoperative coronal alignment, respectively. The subsequently collected data was processed statistically using computer programs and were displayed through narratives, tables, and graphs. Statistical tests used were independent-t test, Wilcoxon Signed Rank test, Chi-square, and Mann Whitney test to evaluate the distribution and to compare the variables. The results were considered to be significant if the p-value was less than <0,05 ($p<0,05$). Data analysis was done using IBM® SPSS Statistics 25® program.

Research began by identifying elderly patients undergoing TKA surgery from medical records and patient registers at Wahidin Sudirohusodo Hospital, Makassar as secondary data. Patients who met the research criteria would undergo interview procedures and complete The New Knee Society Score Short Form and Western Ontario and McMaster Osteoarthritis Index (WOMAC) Score questionnaires. The collected data was then measured statistically using independent T-test, Wilcoxon Signed test, Chi-square, and Mann-Whitney test to evaluate the distribution and the comparison of variables measured. The result was then collected, analyzed, then underwent a series of discussions until a final decision was made from the procedure.

Result

Between January 2020 and December 2020, a total of 124 patients underwent total knee arthroplasty surgery. Out of these, 10 patients were unreachable, 2 patients had a history of postoperative infections, and 1 patient had a history of malunion. As a result, the final sample size included for analysis was 111 patients. Preoperative and postoperative coronal angle measurements were performed in accordance with The Knee Society standards, utilizing knee x-ray films.

The subjects analyzed were divided into two groups based on their postoperative coronal alignment: neutral alignment and mild residual alignment. There were no significant differences between the two groups in terms of gender distribution, age, or the specific knee that was operated on.

Table I. Gender distribution of the group

Gender		Category		
		Neutral	Mild	Total
Male	n	12	14	26
	%	18,5%	30,4%	23,4%
Female	n	53	32	85
	%	81,5%	69,6%	76,6%
Total	n	65	46	111
	%	100,0%	100,0%	100,0%

Chi-square test (p = 0,142)
The gender distribution between the two categories did not differ significantly (p>0.05)

Table II. Descriptive Statistics of Age

Category	n	Minimum	Maximum	Mean	SD
Neutral	65	50	92	64,43	9,68
Mild	46	48	92	66,04	9,81

Independent-t test (p=0,392)
The mean age between the two categories did not differ significantly (p > 0.05)

Table III. Distribution of Knee Location

Knee Location	Category	Total

		Neutral	Mild	
Right	**N**	**35**	**23**	**58**
	%	**51,8%**	**45,7%**	**50,5%**
Left	**N**	**30**	**23**	**53**
	%	**48,2%**	**50,0%**	**49,5%**
Total	**N**	**65**	**46**	**111**
	%	**100,0%**	**100,0%**	**100,0%**

Chi-square test (p=0,311)
The distribution of knee location between the two categories did not differ significantly ($p > 0.05$)

This study utilized the Short Form Knee Society Score (SF-KSS) to evaluate outcomes following total knee arthroplasty. The indicators assessed included symptoms, patient satisfaction, and functional ability. The preoperative SF-KSS scores were not significantly different between the two groups. Additionally, the postoperative SF-KSS scores for both groups also showed no significant differences, with $p > 0.05$, as detailed below

Table IV. Comparison of SF-KSS Scores at 3-Year Follow-Up

Variabel		Category	n	Mean	SD	p
Symptom		**Neutral**	**65**	**8,75**	**2,53**	**0,610**
		Mild	**46**	**8,57**	**2,60**	
Satisfaction		**Neutral**	**65**	**7,14**	**1,04**	**0,538**
		Mild	**46**	**7,26**	**1,04**	
Activity		**Neutral**	**65**	**76,15**	**5,90**	**0,323**
		Mild	**46**	**75,15**	**5,77**	
Total		**Neutral**	**65**	**92,05**	**6,60**	**0,419**

		Mild	**46**	**90,98**	**6,66**	

Results of the Statistical Test for The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Score

This score list is divided into three evaluations: pain, stiffness, and physical function. The analysis results indicate no significant differences ($p > 0.05$) between the two groups preoperatively. The postoperative WOMAC scores for both groups also showed no significant differences, with $p > 0.05$, as detailed below.

Tabel V. Comparison of WOMAC Scores at 3-Year Follow-Up

Variabel	Category	n	Mean	SD	p
Pain	**Neutral**	**65**	**5,40**	**1,12**	**0,238**
	Mild	**46**	**5,00**	**1,35**	
Stiffness	**Neutral**	**65**	**1,14**	**1,51**	**0,806**
	Mild	**46**	**1,24**	**1,61**	
Activity	**Neutral**	**65**	**14,80**	**4,06**	**0,985**
	Mild	**46**	**14,13**	**3,95**	
Total	**Neutral**	**65**	**22,23**	**4,98**	**0,733**
	Mild	**46**	**21,22**	**5,43**	

Mann-Whitney test

Discussion

Total knee arthroplasty (TKA) is a highly effective treatment for severe knee osteoarthritis. Traditionally, achieving a neutral knee alignment has been considered a cornerstone of successful TKA outcomes. However, recent studies have explored alternative alignment methods, such as coronal knee alignment, which have also shown promising results. For instance, research has indicated that patients who underwent TKA with coronal alignment reported high levels of satisfaction one year post-surgery, as demonstrated by improvements in HSS, KS knee, and WOMAC pain scores.

The findings of this study indicate that there were no significant differences in pain, stiffness, activity levels, or total scores between patients who underwent TKA with mild residual coronal alignment versus those with neutral alignment. This aligns with the results of Farooq et al. (2023), which also found no substantial improvement in satisfaction above 80%, reporting an 83% satisfaction rate with a minimum follow-up of one year. Additionally, despite the use of advanced technologies such as computer navigation, patient-specific instrumentation, and robotics to achieve more precise neutral alignment, Guratne's research indicates that postoperative dissatisfaction remains at around 20%.

Significant clinical improvements were observed in the SF-KSS satisfaction scale and WOMAC stiffness scores, consistent with the findings of Budhiparama N.C., et al. Their study noted that cultural factors, such as the high knee mobility required in daily activities for the Indonesian population and the challenges in accessing healthcare, often result in patients presenting with advanced stages of osteoarthritis. In such cases, TKA dramatically reduces limitations in patient activities.

While patients generally experience significant improvements in satisfaction following surgery, those with preserved coronal knee alignment (CPAK) may experience greater pain relief and better functional outcomes. Conversely, deviations from the original alignment could lead to less improvement in discomfort, pain, and function compared to maintaining the natural alignment. These findings suggest that surgeons should consider prioritizing patient-specific alignment during TKA to optimize outcomes.

Further supporting this, research by Wan et al. demonstrated that patients with preoperative varus knees who underwent TKA with mild residual varus alignment achieved outcomes similar to or even better than those with neutral alignment. Mild residual varus alignment postoperatively was deemed acceptable for these patients, whereas severe varus alignment should be avoided.

Several studies have highlighted that achieving neutral coronal alignment during TKA is a key factor in patient satisfaction. Specifically, postoperative misalignment of TKA components has been associated with poorer outcomes and early revision surgeries. Cocanour et al., reported on the short- and long-term outcomes of neutral coronal TKA, noting that while there were no significant clinical differences in the first two years postoperatively, a more pronounced decline in clinical outcomes was observed over a ten-year period, not necessarily due to visible bone damage (level 4) in the lateral compartment.

This study has several limitations: potential recall bias during patient interviews, a need for longer follow-up periods to assess implant durability in both groups, and a relatively small sample size that could be expanded to enhance the study's validity.

Conclusion

In conclusion, both the neutral and mild residual mechanical alignment groups did not show significant differences in clinical functional outcomes following total knee arthroplasty. Both groups exhibited the most substantial improvements in patient satisfaction, as indicated by the SF-KSS, and a significant reduction in stiffness, as shown by the WOMAC score. These findings suggest may have the option to preserve more soft tissue structures and bone to achieve mild residual alignment in patients with preoperative knee deformities, rather than pursuing aggressive to attain neutral alignment.

Reference

1. Promish, M., Wang, C. & Guo, Y. Impact of Coronal Alignment in Total Knee Arthroplasty and Functional Outcome. Open J. Orthop. 08, 11–23 (2018).
2. Nishida, K. et al. Remaining mild varus limb alignment leads to better clinical outcome in total knee arthroplasty for varus osteoarthritis. Knee Surgery, Sport. Traumatol. Arthrosc. 25, 3488–3494 (2016).
3. Meneghini, R. M., Grant, T. W., Ishmael, M. K. & Ziemba-Davis, M. Leaving Residual Varus Alignment After Total Knee Arthroplasty Does Not Improve Patient Outcomes. J. Arthroplasty 32, S171–S176 (2017).
4. Becker, R., Tandogan, R. & Violante, B. Alignment in total knee arthroplasty. Knee Surgery, Sport. Traumatol. Arthrosc. 24, 2393–2394 (2016).
5. Schiffner, E. et al. Neutral or Natural? Functional Impact of the Coronal Alignment in Total Knee Arthroplasty. J. Knee Surg. 32, 820–824 (2018).
6. Vanlommel, L., Vanlommel, J., Claes, S. & Bellemans, J. Slight undercorrection following total knee arthroplasty results in superior clinical outcomes in varus knees. Knee Surgery, Sport. Traumatol. Arthrosc. 21, 2325–2330 (2013).
7. Chia, S.-L. & Tay, B. Total knee arthroplasty. Mercer's Textbook of Orthopaedics and Trauma Tenth edition 1176–1185 at https://doi.org/10.1201/b13543-119 (2012).
8. Beaty, J. H. & Canale, S. T. Preface. Campbell's Operative Orthopaedics ix at https://doi.org/10.1016/b978-0-323-03329-9.50003-9 (2008).
9. Lording, T., Lustig, S. & Neyret, P. Coronal alignment after total knee arthroplasty. EFORT open Rev. 1, 12–17 (2017).
10. Parisi, T. J., Jennings, J. M. & Dennis, D. A. Coronal Alignment in TKA: Traditional Principles Versus New Concepts. Reconstr. Rev. 8, (2018).
11. Skyttä, E. T., Lohman, M., Tallroth, K. & Remes, V. Comparison of Standard Anteroposterior Knee and Hip-to-Ankle Radiographs in Determining the Lower Limb and Implant Alignment after Total Knee Arthroplasty. Scand. J. Surg. 98, 250–253 (2009).
12. Colebatch, A. N. et al. Effective measurement of knee alignment using AP knee radiographs. Knee 16, 42–45 (2009).
13. Vasta, S. et al. Outcomes, Complications, and Reoperations After Meniscal Allograft Transplantation. Orthop. J. Sport. Med. 10, 23259671221075310–23259671221075310 (2022).
14. Gulati, D. A., Kamra, D. P., Gupta, D. A., Gautam, D. V. K. & Khare, D. S. The radiological alignment of components after total knee arthroplasty and its relation to functional outcome. Int. J. Orthop. Sci. 5, 47–50 (2019).
15. Kumar, N., Yadav, C., Raj, R. & Anand, S. How to interpret postoperative X-rays after total knee arthroplasty. Orthop. Surg. 6, 179–186 (2014).
16. Manjunath, K. S., Gopalakrishna, K. G. & Vineeth, G. Evaluation of alignment in total knee arthroplasty: a prospective study. Eur. J. Orthop. Surg. & Traumatol. 25, 895–903 (2015).
17. Vandekerckhove, P.-J. T. K. et al. The Impact of Coronal Plane Alignment on Polyethylene Wear and Damage in Total Knee Arthroplasty: A Retrieval Study. J. Arthroplasty 32, 2012–2016 (2017).
18. Insall, J. N., Binazzi, R., Soudry, M. & Mestriner, L. A. Total Knee Arthroplasty. Clin. Orthop. Relat. Res. 192, 13????22 (1985).
19. Waterson, H. B., Clement, N. D., Eyres, K. S., Mandalia, V. I. & Toms, A. D. The early

outcome of kinematicversusmechanical alignment in total knee arthroplasty. Bone & Jt. J. 98-B, 1360–1368 (2016).
20. Lee, S.-S., Lee, H., Lee, D.-H. & Moon, Y.-W. Slight under-correction following total knee arthroplasty for a valgus knee results in similar clinical outcomes. Arch. Orthop. Trauma Surg. 138, 1011–1019 (2018).
21. Schiraldi, M., Bonzanini, G., Chirillo, D. & de Tullio, V. Mechanical and kinematic alignment in total knee arthroplasty. Ann. Transl. Med. 4, 130 (2016).
22. Slevin, O. et al. Neutral alignment leads to higher knee society scores after total knee arthroplasty in preoperatively non-varus patients: a prospective clinical study using 3D-CT. Knee Surgery, Sport. Traumatol. Arthrosc. 26, 1602–1609 (2017).
23. Ro, D. H. et al. Residual varus alignment after total knee arthroplasty increases knee adduction moment without improving patient function: A propensity score-matched cohort study. Knee 26, 737–744 (2019).
24. Zhang, Z. et al. Residual Mild Varus Alignment and Neutral Mechanical Alignment Have Similar Outcome after Total Knee Arthroplasty for Varus Osteoarthritis in Five-Year Follow-Up. J. Knee Surg. 33, 200–205 (2019).
25. Slevin, O., Amsler, F. & Hirschmann, M. T. No correlation between coronal alignment of total knee arthroplasty and clinical outcomes: a prospective clinical study using 3D-CT. Knee Surgery, Sport. Traumatol. Arthrosc. 25, 3892–3900 (2016).
26. Abdel, M. P. et al. Effect of Postoperative Mechanical Axis Alignment on Survival and Functional Outcomes of Modern Total Knee Arthroplasties with Cement. J. Bone Jt. Surg. 100, 472–478 (2018).
27. EWALD, F. C. The Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System. Clin. Orthop. Relat. Res. 248, 9???12 (1989).
28. Zhang, Y. Validation of the new knee society knee scoring system for outcome assessment after total knew arthroplasty. (The University of Hong Kong Libraries). doi:10.5353/th_b5091624.
29. Carr, A. J. et al. Knee replacement. Lancet 379, 1331–1340 (2012).
30. Kim, S. E., Yun, K.-R., Lee, J. M., Lee, M. C. & Han, H.-S. Preserving coronal knee alignment of the knee (CPAK) in unicompartmental knee arthroplasty correlates with superior patient-reported outcomes. Knee Surg. Relat. Res. 36, 1 (2024).
31. Farooq, H., Deckard, E. R., Carlson, J., Ghattas, N. & Meneghini, R. M. Coronal and Sagittal Component Position in Contemporary Total Knee Arthroplasty: Targeting Native Alignment Optimizes Clinical Outcomes. J. Arthroplasty 38, S245–S251 (2023).
32. Gunaratne, R. et al. Patient Dissatisfaction Following Total Knee Arthroplasty: A Systematic Review of the Literature. J. Arthroplasty 32, 3854–3860 (2017).
33. Budhiparama, N. C. et al. A comparison of clinical and patient-reported outcome measures of TKR: Comparison of Asian to North American patients. J. Orthop. Surg. 27, 230949901984455 (2019).
34. Wan, X.-F. et al. Comparison of Outcomes After Total Knee Arthroplasty Involving Postoperative Neutral or Residual Mild Varus Alignment: A Systematic Review and Meta-analysis. Orthop. Surg. 14, 177–189 (2022).
35. Hadi, M. et al. Does malalignment affect patient reported outcomes following total knee arthroplasty: a systematic review of the literature. Springerplus 5, 1201 (2016).
36. Cocanour, C. S. et al. Management and Novel Adjuncts of Necrotizing Soft Tissue

Infections. Surg. Infect. (Larchmt). 18, 250–272 (2017).