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# Over-Constraint Varus-Valgus Laxity Leads to Worse Clinical Outcomes at Long-Term Follow-Up in Total Knee Arthroplasty: Intraoperative Assessment through Surgical Navigation System

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**Abstract**

The purpose of the present study was to associate the intraoperative kinematics acquired with a computer navigation system with long-term clinical outcomes and survivorship in patients undergoing TKA to investigate the role of constraint in patients' satisfaction.

A surgical navigation system was used to verify bone resections, gaps, and implant positioning during TKA. Kinematic examination, i.e. varus-valgus at full-extended knee (VV0), varus-valgus at 30° of flexion (VV30), anterior/posterior displacement at 90° of flexion (AP90), passive range of motion (ROM) were performed. Long-term clinical assessment interviews were performed. The Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to investigate patients' clinical and functional status.

Out of 165 patients, 120 met the inclusion criteria. The average follow-up time was 7.7±2.8 years. 7 patients had undergone revision surgery and were considered as a surgical failure with an overall survival rate of 94.2%, while the survival rate at 6, 8, 10 years was 98.8%, 97.4%, 93.6%, respectively. Clinical failure (KOOS score <70) was detected in 11 (9.2%), 10 (8.3%), 21 (17.5%), 39 (32.5%), 113 (94.2%) patients for the Symptoms, Pain, ADL, QoL, and Sport sub-scores, respectively. A statistically significant difference was found in KOOS-QoL between patients with and without clinical failure for the VV0 test (ES=0.58, p=0.022), with lower laxity for patients with score<70.

[*] Masterminded EasyChair and created the first stable version of this document
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Over-constraint kinematics during TKA surgery leads to worse clinical outcomes at long-term follow-up. Surgeons should be aware of the intraoperative ligament balancing and avoid over-constraint, especially in PS TKA designs.

# 1 Introduction

Total knee arthroplasty (TKA) is the gold standard for treating end-stage osteoarthritis. Despite the overall successes of TKA, approximately 20% of patients are still dissatisfied with the results of their surgery (Y.-H. Kim et al., 2020). Computer-assisted surgery (CAS) devices have been developed to support surgeons in achieving accurate and reproducible TKA surgery, with the aim of reducing postoperative complications and patients' dissatisfaction. The role of knee laxity has also gained overwhelming importance in predicting TKA failure and implant stability (Kappel et al., 2019). The few studies investigating in-vivo intraoperative laxity through navigation systems reported negligible kinematical differences between different TKA designs and limited association with postoperative clinical outcomes (Ishii et al., 2017; T. W. Kim et al., 2016). Currently, 2 years was the maximum follow-up reported for clinical outcomes, and no literature is available on the association between intraoperative knee kinematics and long-term clinical outcomes and survivorship. The purpose of the present study was to associate the intraoperative kinematics acquired with a computer navigation system with long-term clinical outcomes and survivorship in patients undergoing TKA to investigate the role of constraint in patients' satisfaction.

# 2 Methods

A series of navigated TKA surgeries performed between 2005 and 2021 was retrospectively screened for eligibility. A surgical navigation system was used to verify bone resections, gaps, and implant positioning during TKA. Kinematic examination, i.e. varus-valgus at full-extended knee (VV0), varus-valgus at 30° of flexion (VV30), anterior/posterior displacement at 90° of flexion (AP90), passive range of motion (ROM) were performed. Long-term clinical assessment interviews were performed. The Knee Injury and Osteoarthritis Outcome Score (KOOS) was used to investigate patients' clinical and functional status. Survival analysis was conducted via Kaplan-Meier method with reoperation as endpoint representing the surgical failure. The mean estimated survival time was calculated from the Kaplan-Meier curves. The clinical failure was also investigated via KOOS score: a score below 70 points was considered clinical failure for each sub-score. The two-tailed Student's t-test was used to assess the statistical differences in the laxity tests conducted by means of the surgical navigation system between patients with scores below and over 70 per each sub-score. Moreover, a two-step cluster analysis was applied to define a natural laxity profile for patients with and without clinical failure. The five sub-scores of the KOOS score with relative thresholds (below/over 70) were used to cluster the laxity data from the four kinematical tests. A silhouette coefficient was computed to define the consistency of the cluster separation.

# 3 Results

Out of 165 patients, 120 met the inclusion criteria. The average follow-up time was 7.7±2.8 years. 7 patients had undergone revision surgery and were considered as a surgical failure with an overall survival rate of 94.2%, while the survival rate at 6, 8, 10 years was 98.8%, 97.4%, 93.6%, respectively (Figure 1). Clinical failure (KOOS score <70) was detected in 11 (9.2%), 10 (8.3%), 21 (17.5%), 39 (32.5%), 113 (94.2%) patients for the Symptoms, Pain, ADL, QoL, and Sport sub-scores, respectively. A statistically significant difference was found in KOOS-QoL between patients with and without clinical failure for the VV0 test (ES=0.58, p=0.022), with lower laxity for patients with score<70. The two-step clustering successfully separated the laxity results into two groups (Table 1), with a silhouette coefficient of 0.3 (fair).

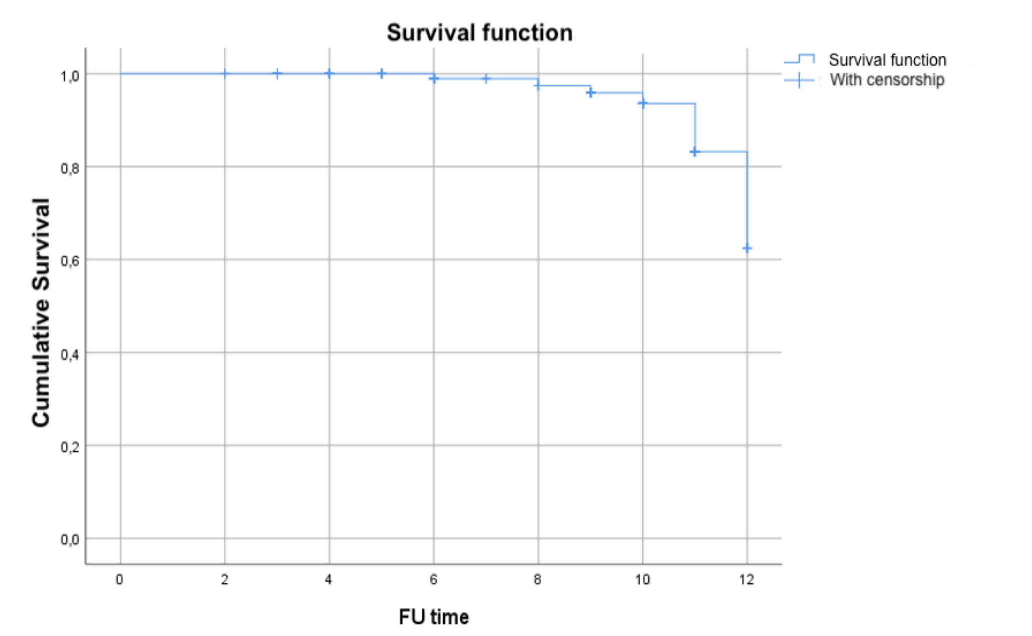


**Figure 1:** Cumulative survivorship of the navigated TKA

# 4 Discussion and Conclusion

The most important finding of the present study was that lower laxity in the VV0 test was found in patients with KOOS <70 (considered clinical failure) than patients without clinical failure, while the other laxity parameters remained comparable. Thus, an over-constraint kinematics during TKA surgery might lead to worse clinical outcomes and patients' dissatisfaction. Thus, the hypothesis of greater laxity associated with clinical failure was not confirmed.

The present study was the first to investigate the association between intraoperative kinematics during TKA surgery and clinical outcomes at long term follow-up (average 7.7 years) in a large cohort of subjects. Overall, knee stability is a primary outcome of TKA surgery and has been previously linked to postoperative outcomes (Seah et al., 2014). No consensus exists on the minimum VV laxity that should be achieved to guarantee knee stability.

Moreover, group clustering showed that over-constraint VV0 (below 3°) was the only laxity difference accounting for overall clinical failure (all KOOS sub-scores<70). A varus-valgus lower than 3° might therefore identify a knee that is too tight or, conversely, is non-optimally released. Such an over-constraint might limit the flexion-extension movements or bring a non-physiologic load acceptance phase, affecting patients' overall quality of life.

Over-constraint kinematics during TKA surgery leads to worse clinical outcomes at long-term follow-up. Surgeons should be aware of the intraoperative ligament balancing and avoid over-constraint, especially in PS TKA designs.

| Laxity test | Group 1 (No clinical failure) | Group 2 (Clinical failure) |
|---|---|---|
| VV 0 (°) | 3.4±1.7 | 2.7±1.1 |
| VV 30 (°) | 4.4±2.0 | 4.3±1.8 |
| AP 90 (°) | 7.9±3.3 | 7.2±3.7 |
| ROM (°) | 112.1±9.1 | 115.1±6.4 |

**Table 1.** Laxity data clustering based on clinical failure (KOOS <70)

# References


Ishii, Y., Noguchi, H., Sato, J., Sakurai, T., & Toyabe, S.-I. (2017). Anteroposterior translation and range of motion after total knee arthroplasty using posterior cruciate ligament-retaining versus posterior cruciate ligament-substituting prostheses. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, *25*(11), 3536–3542. https://doi.org/10.1007/s00167-016-4257-0

Kappel, A., Laursen, M., Nielsen, P. T., & Odgaard, A. (2019). Relationship between outcome scores and knee laxity following total knee arthroplasty: A systematic review. *Acta Orthopaedica*, *90*(1), 46–52. https://doi.org/10.1080/17453674.2018.1554400

Kim, T. W., Lee, S. M., Seong, S. C., Lee, S., Jang, J., & Lee, M. C. (2016). Different intraoperative kinematics with comparable clinical outcomes of ultracongruent and posterior stabilized mobile-bearing total knee arthroplasty. *Knee Surgery, Sports Traumatology, Arthroscopy: Official Journal of the ESSKA*, *24*(9), 3036–3043. https://doi.org/10.1007/s00167-014-3489-0

Kim, Y.-H., Yoon, S.-H., & Park, J.-W. (2020). 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*(2), 266–275. https://doi.org/10.1097/CORR.0000000000000916

Seah, R. B., Yeo, S. J., Chin, P. L., Yew, A. K. S., Chong, H. C., & Lo, N. N. (2014). Evaluation of medial-lateral stability and functional outcome following total knee arthroplasty: Results of a single hospital joint registry. *The Journal of Arthroplasty*, *29*(12), 2276–2279. https://doi.org/10.1016/j.arth.2014.04.015