Original Article

Correlation of Preoperatively Predicted and Intraoperative Soft-Tissue Releases in Total Knee Arthroplasty

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Abstract

Objectives: Soft-tissue balancing is one of the key components to achieving a successful total knee arthroplasty (TKA), but the planned soft-tissue release may not always correlate with the required releases intraoperatively to achieve a balanced knee. The aim of our study is to explore whether these required releases can be predicted accurately preoperatively and if their accuracy correlates with the level of training. **Methods:** Two hundred and fifty-one patients undergoing primary TKA were included in the study. Preoperatively, the consultant, fellow, and resident independently predicted the required releases to gain a balanced knee. Postoperatively, the performed releases were recorded and compared to the preoperative predictions. **Results:** Consultants had the highest exact match (62%), while the fellows and residents were less accurate (57% and 58%, respectively). Fellows and consultants had the least deviation of their prediction from the performed soft-tissue release. The intraclass correlation coefficients were also highest for consultants, followed by fellows and then residents, but this was not statistically significant. **Conclusion:** We found that participants irrespective of their level of training were able to accurately predict the required soft-tissue balancing in TKA. We believe this can be a valuable educational and assessment tool for trainees at all levels.

Keywords: Balancing, education, prediction, release, replacement, total knee arthroplasty

Introduction

Symptomatic osteoarthritis (OA) of the knee is commonly managed successfully by a total knee arthroplasty (TKA), but several requirements must be met to achieve this successful outcome. These criteria include adequate alignment, soft-tissue balancing, and restoration of the native joint line.[1-3] To achieve adequate intraoperative soft-tissue balancing, the preoperative alignment of the patient must be adequately assessed, as the majority of patients suffering from knee OA typically present with medial compartmental involvement and thus present with some degree of preoperative varus alignment. While correcting the coronal alignment to a neutral one at the time of TKA has been debated in the current literature,[4-8] most of the surgeons still aim to correct coronal alignment to a neutral mechanical axis. Thus, the medial soft-tissue structures must be released to balance the knee properly.[1]

There is no universally acceptable progression for the order of soft-tissue releases. Surgeons follow general guidelines typically starting with the release of the deep medial collateral ligament (MCL) and removal of osteophytes, but progression beyond this varies between centers and surgeons.[9]

The objective of our current study is to examine whether the required soft-tissue balancing in TKA can be predicted accurately before surgery and if the level of training in adult joint reconstruction influences the accuracy of this prediction. To the best of our knowledge, this is the first study to assess the soft-tissue balancing prediction in TKA at different training levels.

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Materials and Methods

After obtaining ethics approval from the institutional research ethics board, 251 patients undergoing primary TKA were included in the study. All procedures were conducted at a single center by three adult reconstructive fellowship-trained orthopedic surgeons. All patients, with no history of knee surgery or lower extremity trauma, who required TKA for varus OA of the knee and had neutral or varus alignment of their lower extremity as indicated by the preoperative hip to ankle radiographs were included in the study. Prior to each surgery, the attending consultant, fellow, and resident independently recorded the predicted soft-tissue and bone modifications required to achieve a balanced knee. The participants did not discuss the case before recording their predictions, the recording was done without the presence of the other participants, and no changes in the recorded predictions were allowed. Predictions were based solely on information from the patient's chart, clinical examination, and preoperative radiographs. The actual soft-tissue and bone modifications were performed as required to create a balanced knee intraoperatively and the releases were then recorded. The steps to balance the knee were done according to the traditional sequence followed by the arthroplasty surgeons at our center [Table 1].[9] Data were coded according to the most extensive grade of balancing step the patient received.

The frequency of each modification was calculated and reported using descriptive statistics. Percentages of exact matches between the predicted and actual soft-tissue modifications completed were reported for consultants, fellows, and residents. The percentage of being ±1 release was also reported for each group. Intraclass correlation coefficients (ICCs) and their 95% confidence intervals were calculated for consultants, fellows, and residents. ICC estimates and their 95% confidence intervals were calculated using the Statistical Package for the Social Sciences version 24 (SPSS Inc., Chicago, IL, USA) based on a single-rater, absolute-agreement, 2-way random-effects model.

Table 1: Sequence of soft-tissue modification applied in our current study

Modification Grade	Description
Grade 1	50% deep medial collateral ligament release up to the mid-coronal tibial plane AND Osteophytes (tibial and femoral)
Grade 2	Complete deep medial collateral ligament release AND/OR Posterior capsule release AND/OR Semimembranosus and posterior oblique ligament release
Grade 3	Tibial reduction osteotomy AND/OR Superficial medial collateral ligament release AND/OR Medial epicondyle osteotomy

Table 2: Soft-tissue modification intraclass correlation coefficients for residents, fellows, and consultants

Level of experience	ICC	95% CI	
		Lower bound	Upper bound
Resident (SR)	0.461	0.301	0.594
Fellow (SR)	0.547	0.431	0.641
Consultant (SR)	0.596	0.502	0.676
Resident (AR)	0.631	0.463	0.745
Fellow (AR)	0.707	0.602	0.781
Consultant (AR)	0.747	0.668	0.807

ICC: Intraclass correlation coefficient, SR: Single rater, AR: Average rater, CI: Confidence interval

Results

Of the 251 cases, 18 knees (7%) received 50% deep MCL mid-coronal plane release and 85 knees (34%) received osteophyte (tibial and femoral) removal. Of the remaining cases, 64 knees (25%) received complete deep MCL release, 28 knees (11%) received posterior capsule release, and 23 knees (9%) received semimembranosus and posterior oblique ligament release. A more extensive modification was required in 33 knees, of which 22 (9%) received a tibial reduction osteotomy, 7 (3%) received superficial MCL release, and 4 (2%) received a medial epicondyle osteotomy.

Consultants, fellows, and residents were able to exactly match their prediction to the actual soft-tissue balancing in 62%, 57%, and 58% of the cases, respectively. Consultants, fellows, and residents were able to predict the soft-tissue balancing within ±1 release in 80%, 81%, and 79% of the cases, respectively. The ICC was highest for the consultants (single rater (SR) = 0.596, average rater (AR) = 0.747), followed by the fellows (SR = 0.547, AR = 0.707) and finally, the residents (SR = 0.461, AR = 0.631) with no statistically significant difference between them [Table 2].

Discussion

Our current study has shown that the ability to correctly predict the required soft-tissue release in patients undergoing TKA was lowest by the residents and fellows involved (58% and 57%, respectively) and the accuracy was higher for the consultants (62%). In addition, the ICC showed a gradual improvement in accuracy as we progressed into higher levels of training, from residents to fellows and finally to consultants, although it did not reach clinical significance.

Correctly predicting the required soft-tissue releases in TKA requires a thorough understanding of the knee's anatomy and mechanics. Therefore, the concept of preoperative prediction of releases to gain a balanced knee can be applied as an element of both trainee education and assessment. With a large number of programs trending toward competency-based training, this tool can act as a way to measure resident and/or fellow progression and understanding of the several concepts encompassed in

TKA soft-tissue balancing. This type of training is especially useful to aid in vocational learning, which is an integral part of medical training programs.[10]

Academic teaching, patient-centered care, and intraoperative teaching and skill practice are considered the cornerstone of residency and fellowship training programs.[11,12] Specific attention has been directed recently toward surgical simulation and its role in both teaching and assessing trainees, showing improved knowledge and skills compared to formal teaching methods.[13-15] Applying the concept and understanding of releases required to gain a balanced TKA can be presented in the form of a simulation program to assess the trainee's knowledge of both required and sequence of releases. In addition, it can also provide a platform for trainees to perform and evaluate these releases on the simulator, with an ultimate goal of achieving a balanced knee arthroplasty.

Concerning its application in a more formal teaching style, this method of prediction may help foster an optimal learning environment in the operating room and bring about the discussion about one of the more variable aspects of the TKA procedure. This, in turn, will help the trainee gain a better understanding of the principles involved in TKA soft-tissue balancing.

We recognize that there are limitations to this study. There was no objective assessment of the soft-tissue tension and required release, which may have led to a stronger influence of the consultant surgeon on the performed releases. Having an objective tool to assess the knee balance after the release may have minimized this potential bias. Furthermore, since the consultant ultimately performs the soft-tissue balancing after making the prediction, this could have made the consultant appear more accurate than their trainees. Surprisingly, we found no statistically significant difference in the accuracy of prediction between the different participant levels.

Conclusion

Irrespective of the level of training, the participants were able to accurately predict the required soft-tissue balancing in TKA. The resident level had the lowest ability to predict the necessary soft-tissue releases accurately, while consultants had the highest prediction ability, but this did not reach statistical significance. We believe that this can be a valuable educational tool to assess the trainees' understanding of soft-tissue balancing concepts and assess progression through the different levels of training under the umbrella of competency-based training.

Ethical approval

This study has been approved by The Western University Research Ethics Board on 3rd June 2020 under the IRB registration number IRB 00000940. Patient consent was obtained for all participants and is compliant with the Declaration of Helsinki.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

MMA, TJW, and LES collected, organized, analyzed, and interpreted data. JLH, EMV, and BAL conceived and designed the study, conducted research, provided research materials and MMA and TJW wrote the initial and final draft of the article and provided logistic support. All the authors have critically reviewed and approved the final draft and are responsible for the manuscript's content and similarity index.

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