

Digital templating of rotating hinge revision and primary total knee arthroplasty

Peter Savov,¹ Henning Windhagen,¹
Carl Haasper,² Max Ettinger¹

¹Department of Orthopedic Surgery, Hannover Medical School; ²Department of Joint Surgery, AMEOS Clinic Seepark Geestland, Germany

Abstract

Preoperative digital templating in total knee arthroplasty (TKA) is useful in predicting implant size, the level of bone resections and the need for special implants. This study should evaluate the templating of a rotating hinge prosthesis and the realization of the preoperative plan. Two observers with different experience levels templated 40 cases which received TKA and R-TKA using digital planning on standard preoperative x-rays. The examiners templated all cases independently and were blinded to the component sizes used intraoperatively. The kappa coefficient and Pearson coefficient were determined. The accuracy in predicting the correct implant size in revision TKA varied from 67,9% to 82,1% depending on the training level of the observer. The two observers show *moderate* and *substantial* correlation. The coefficient indicates a substantial agreement in between the two observers in templating revision TKA. The accuracy depends on the experience of the observer. In the cases where the templating was incorrect, the prosthesis was implanted smaller than the preoperative plan. With this knowledge very good results can be made with this prosthesis.

Introduction

Digital templating is a standard tool in total knee arthroplasty (TKA). In the process of digitization, the picture archiving and communication system (PACS) is widely used for the administration of X-ray images. Preoperative digital templating is useful in predicting implant size, the level of bone resections, the need for special implants, and the intraoperative anticipation of the plan.^{1,2} The measurement of anterior-posterior and lateral radiographs is standard.³ However, preoperatively measured variables often do not match with the definitive size, thus they should be considered as a guideline. If the accuracy is extended to within one size, however, very good match-

ing is obtained.^{1,4-7} In the case of revision TKA, however, the accuracy and reliability of templating may be limited.⁷ If a similar accuracy, compared to primary TKA, is achieved in revision templating, a reduction of implants and trays may be possible. This can lead to a considerable cost decrease.^{6,8,9} However, only one templating study about revision TKA with a low number of cases has been published so far.⁷ The experience of the observer is discussed as a further critical point in the literature on templating accuracy. An older study showed significant differences between the different training levels of the examiner, although recent studies failed to confirm this effect.^{2,9,10} The variability in x-ray quality and enlargement can also have an influence on the measurement accuracy and reproducibility of the results.² Rotating hinge prostheses are mainly used in revision surgery. In case of instability and complicated soft tissue balancing, they can also be used in primary TKA.^{11,12} Data about the templating accuracy of rotating hinge prosthesis is scarce, in primary and revision TKA. The Link Endo-Modell rotating hinge prosthesis comes in only four different sizes. This leads to a small implant depot. The aim of this study was to evaluate the precision of templating this prosthesis in primary TKA and revision TKA and the realization of the preoperative plan. Further, the training level of the observer was evaluated.

Materials and Methods

Between 01/2014 and 05/2017, 60 patients were operated with the LINK Endo-modell® rotation hinge prosthesis at two centers. The prosthesis was used in primary and revision TKA. All procedures were done by 3-4 experienced surgeons. Data collection was retrospective. All patients with primary or secondary osteoarthritis or patients with failed primary TKA which were operated with a LINK Endo-modell® rotation hinge prosthesis were included in this study. Derotated x-rays were the only exclusion criteria. After reviewing the x-rays, 40 patients were included in this study. The prosthesis has four different sizes and the components of femur and tibia cannot be combined in different size. All patients received preoperatively standard x-ray with a 25mm or 30mm metal ball for referencing. X-rays included an anterior-posterior view, a lateral view, a patella tangential view and a long-leg view. Two observers with different experience levels performed the preoperative templating: one senior surgeon and one sixth month

Correspondence: Peter Savov, Department of Orthopedic Surgery, Hannover Medical School, 1-7 Anna-von-Borries Street, Hanover 30625, Germany.
Tel.: +49.511.53540; Fax: +49.511.5354682.
E-mail: peter@savov-medizin.de

Key words: Templating, training level, total knee arthroplasty, knee revision arthroplasty, template directed instrumentation.

Contributions: the authors contributed equally.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: none.

Received for publication: 6 August 2018.
Accepted for publication: 20 October 2018.

This work is licensed under a Creative Commons Attribution NonCommercial 4.0 License (CC BY-NC 4.0).

©Copyright P. Savov et al., 2018
Licensee PAGEPress, Italy
Orthopedic Reviews 2018;10:7811
doi:10.4081/or.2018.7811

resident (Figure 1). The investigations were carried out independently and have been blinded in relation to the size finally used. The software OrthoView digital planning (OrthoView LLC, Jacksonville, Florida) was used for templating. Data processing was performed using the spreadsheet program Microsoft Office Excel 2013 (Microsoft Co., Redmond, WA). The statistical evaluation was carried out with the software IBM SPSS Statistics 21 (IBM Co., Armonk, NY). The Pearson coefficient was calculated to determine the correlation between templated and actually sizes. The kappa coefficient was also calculated to evaluate the inter-observer validity. Frequency distribution analyses were performed as well.

Table 1. Coefficients and level of agreement.

Coefficients	Level
0	poor
0 - 0,2	slight
0,2 - 0,4	fair
0,4 - 0,6	moderate
0,6 - 0,8	substantial
0,8 - 1,0	very good

Table 2. Pearson correlation between templated and actual size.

Correlation		Actual size vs. 6 th month resident	Actual size vs. senior surgeon	6 th month resident vs. senior surgeon
All cases	Pearson Coefficient	0,570	0,781	0,806
	Signification	0,00	0,00	0,00
Primary TKA	Pearson Coefficient	0,493	0,557	0,885
	Signification	0,148	0,094	0,001
Revision TKA	Pearson Coefficient	0,599	0,846	0,780
	Signification	0,001	0,00	0,00

Results

In Table 1 coefficients and level of agreement are shown. The Pearson coefficients for the two observers are shown in Table 2. The 6th month resident shows a *moderate* and the senior surgeon a *substantial* correlation to the actual size of all cases. If only the primary TKAs are considered, there are *moderate* correlations. However, these are not significant. The revision TKA shows a *moderate* correlation with the 6th month resident and a *substantial* correlation with the senior surgeon. The coefficients indicate a very good agreement between the accuracy of the two observers in all examinations. For the inter-observer validity, the kappa coefficient was used. The results are shown in Table 3. The accuracy is shown in Table 4. It differs between the observers. Both in the primary TKAs and the revision TKAs, the senior surgeon has a higher accuracy than the 6th month resident. Overall, the prostheses were more often templated too large.

Discussion

The most important findings of this study are that the LINK Endo model rotating hinge prosthesis for the revisions TKA can be templated very well. The accuracy, however, depends on the experience of the observer. This study is the first to investigate the preoperative templating of the LINK Endo-modell prosthesis. This rotating hinge prosthesis is primarily used for revision TKA, but may also be used in complicated primary cases. Particularly when a very high instability is present.¹¹ In this study, TKA and R-TKA have been retrospectively examined for templating accuracy. Preoperative templating is a well-studied and important tool in primary resurfacing TKA. Many studies focused on the accuracy and reproduction of templating for TKA.^{2,4-6,9,10,13} However, there is only one study in the literature dealing with preoper-

Table 3. Inter-observer validity.

Correlation		Senior surgeon vs. 6 th month resident
All cases	Kappa Coefficient	0,711
	Signification	0,00
Primary TKA	Kappa Coefficient	0,825
	Signification	0,001
Revision TKA	Kappa Coefficient	0,667
	Signification	0,00

Table 4. Frequency distribution.

Accuracy		6 th month resident, %	Senior surgeon, %
All cases	Accurate	25 (65,8)	30 (78,9)
	1 bigger	10 (26,3)	6 (15,5)
	1 smaller	3 (7,9)	2 (5,3)
Primary TKA	Accurate	6 (60)	7 (70)
	1 bigger	3 (30)	2 (20)
	1 smaller	1 (10)	1 (10)
Revision TKA	Accurate	19 (67,9)	23 (82,1)
	1 bigger	7 (25)	4 (14,3)
	1 smaller	2 (7,1)	1 (3,6)

ative templating revision TKA and high constrained models.⁷ Jain *et al.* conducted the measurement on 10 revision cases. In the present study, 30 R-TKA and 10 TKA were examined. Different results are published about templating accuracy. If the accuracy is determined to the exact size, data differ from 42 to 68%.^{1-6,9,10} Templating of the tibia is usually more accurate than of the femur. The different diameters of the lateral and medial femoral condyle are discussed as one of the causes. Furthermore, the bony landmarks are more difficult to define.^{5,9} Another reason for the inconsistent data is seen in the quality of x-rays. Enlargement and rotation play a crucial role.^{2,9} If the accuracy is determined within one size, the accuracy in the literature increases to 88-93%. These results are considered satisfactory.^{1,2,5,9,10} Due to the low accuracy, the results are interpreted as indicative of the size to be implanted rather than a definitive prediction.⁶ Jain *et al.* published an accuracy of 46.8% (femur) and 41.9% (tibia) for revision TKA. They see

the accuracy of the planning as too insufficient to make reliable predictions. The reason for this is, in addition to the general difficulties, the preoperatively unpredictable bone loss during the exploration of the in-situ prosthesis.⁷ Why the accuracy of the tibial component is less than that of the femoral component stays unclear. In the present study, the accuracy of templating the exact size for primary TKA differs from 60 to 70%. The accuracy for revision TKA differs from 67.9 to 82.1%. If all cases are considered together, the values are 65.8 and 78.9%, respectively. The Pearson correlation between the templating of the 6th month resident in revision TKAs and the actual size is considered as *moderate* in this study. On the other hand, the senior surgeons templating is *substantial*. Due to the low number of patients, no significant correlation was evaluated for primary TKA. The results coincide with a comparable study.⁷ However, the data of the present study must be considered in terms of the fact that four different sizes of the prosthesis exist and

that these cannot be combined with each another. As a result, a decision must be made in the case of a discrepancy between the femoral and tibial components. The experience of the observer seems to play a significant role in templating. Compromises in the determination of the size must therefore be made both femoral, tibial and in combination. Experience has shown that the templating of the femoral component predominantly takes place in the lateral X-ray image, thus anterior posterior size. Intraoperatively, however, the size determination is primarily performed over the width of the condyles. This can explain the deviation between the planning and the actually implanted size. In cases where templating does not match the actual size, the components were planned too large (Table 4, Figures 2-4).

Nevertheless, the values are comparable with those of the literature and seem to be slightly higher. The kappa coefficient was ascertained to evaluate the inter-observer validity. Overall, there was a *substantial* correlation. This means that the investigators planned a high percentage of the same

cases correctly and incorrectly. This confirms to the theory above. The role of the investigator's experience was not evaluated a lot yet. Ettinger *et al.* and Hsu *et al.* could not detect any significant differences between the different training levels in templating accuracy. Both clinical beginners and senior knee surgeons have been able to achieve similar results.^{2,9} Carter *et al.* in contrast, published a certain difference. The accuracy varied according to the experience level from 82% to 95%.¹⁰ In the present study, a difference between the experience levels of the observers was also found. The senior surgeon was able to achieve higher accuracy for both primary TKAs and R-TKAs. In addition, the templating of the senior surgeon has a substantial correlation with the current size. In contrast, the 6th month resident only has a moderate correlation.

The templating and the associated prediction of the prosthesis size could have an impact on the cost efficiency. Hsu *et al.* published a study on the templated-directed instrumentation (TDI). For the two most commonly used prosthesis sizes, three light-

weight trays were provided by the manufacturer only with the most necessary instruments. The number of trays used was finally documented. In 97% of the cases, the trays and instruments provided were adequate. A cost analysis was carried out. With the aid of the TDI, the costs for the preparation, sterilization and packing of the trays could be reduced by more than double.⁸ This makes the economic relevance of templating remarkable. The results of this study do not currently allow any TDI to implant the LINK Endo model knee prosthesis.

This study has limitations. Due to the low number of patients of primary TKA, only limited valid statements can be made. A larger number of patients is necessary to confirm or refute the statements. This is very difficult because of the very strict indication of the prosthesis for primary care. Furthermore, the quality of X-ray images can have an influence on the measurement accuracy of the examiners. The component of the rotation has already been shown. The intra-observer validity was not determined.

Conclusions

In summary, the LINK Endo model rotating hinge prosthesis for TKA and R-TKA can be templated very well. The accuracy, however, depends on the experience of the observer. In the cases where the templating was incorrect, the prosthesis was implanted smaller than the preoperative plan. The following relationship could be possible: the preoperative templating takes place in the sagittal plane at the femur. However, the intraoperative size determination happened in the frontal plane. The prosthesis shows a mismatch for some individual anatomic situations. As a consequence, the femoral component could be in the sagittal plane slightly to small. The size of the tibia has to be the same as the femur. Consequently, compromises have to be made in some cases. With this knowledge very good results can be made with this prosthesis.

References

1. Specht LM, Levitz S, Iorio R, et al. A comparison of acetate and digital templating for total knee arthroplasty. *Clin Orthop Relat Res* 2007;464:179-83.
2. Hsu AR, Kim JD, Bhatia S, et al. Effect of training level on accuracy of digital templating in primary total hip and knee arthroplasty. *Orthopedics* 2012;35:e179-83.

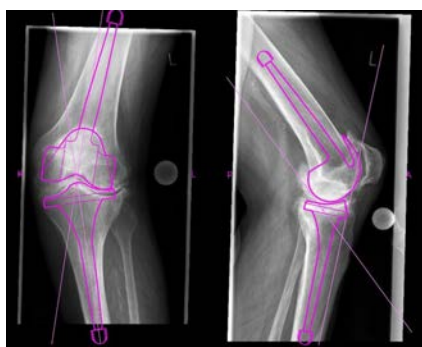


Figure 1. Templating for a primary TKA with a rotating hinge prosthesis.

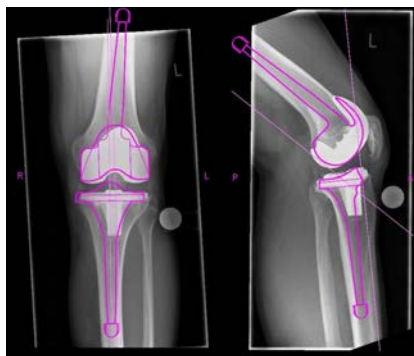


Figure 2. Templating for a revision TKA with a rotating hinge prosthesis.

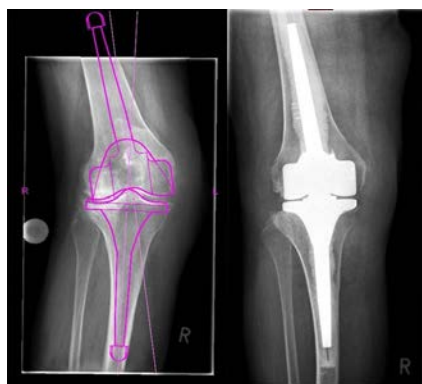


Figure 3. Pre and post-surgery x-ray in anterior-posterior view after primary TKA with templated size L and actual size M.



Figure 4. Pre and post-surgery x-ray in lateral view after primary TKA with templated size L and actual size M.

3. Heal J, Blewitt N. Kinemax total knee arthroplasty: trial by template. *J Arthroplasty* 2002;17:90-4.
4. Arora J, Sharma S, Blyth M. The role of pre-operative templating in primary total knee replacement. *Knee Surg Sports Traumatol Arthrosc* 2005;13:187-9.
5. Trickett RW, Hodgson P, Forster MC, et al. The reliability and accuracy of digital templating in total knee replacement. *J Bone Joint Surg Br* 2009;91:903-6.
6. Howcroft DW, Fehily MJ, Peck C, et al. The role of preoperative templating in total knee arthroplasty: comparison of three prostheses. *Knee* 2006;13:427-9.
7. Jain NP, Guyver PM, McCarthy MJ, et al. The accuracy and reliability of pre-operative templating in revision total knee arthroplasty. A comparison of analogue and digital methods. *J Orthop* 2014;11:121-5.
8. Hsu AR, Gross CE, Bhatia S, et al. Template-directed instrumentation in total knee arthroplasty: cost savings analysis. *Orthopedics* 2012;35:e1596-600.
9. Ettinger M, Claassen L, Paes P, et al. 2D versus 3D templating in total knee arthroplasty. *Knee* 2016 23:149-51.
10. Carter LW, Stovall DO, Young TR. Determination of accuracy of preoperative templating of noncemented femoral prostheses. *J Arthroplasty* 1995;10:507-13.
11. Bistolfi A, Lustig S, Rosso F, et al. Results with 98 Endo-Modell rotating hinge prostheses for primary knee arthroplasty. *Orthopedics* 2013;36:e746-52.
12. Bistolfi A, Rosso F, Crova M, et al. Endo-Modell rotating-hinge total knee for revision total knee arthroplasty. *Orthopedics* 2013;36:e1299-306.
13. The B, Diercks RL, van Ooijen PM, et al. Comparison of analog and digital preoperative planning in total hip and knee arthroplasties. A prospective study of 173 hips and 65 total knees. *Acta Orthop* 2005;76:78-84.