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Original article

# Fallacies of CT based component size prediction in total knee arthroplasty – Are patient specific instruments the answer?

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ABSTRACT

*Background:* The purpose of the study was to assess the accuracy of tibial and femoral component size prediction using computerised tomography (CT) based patient specific instruments in total knee arthroplasty.
*Methods:* Eighty-eight knees in 58 patients underwent total knee arthroplasty (TKA) using CT based patient specific instruments between March 2015 to April 2016. All patients were assessed for the pre operative femoral and tibial component sizes predicted by the CT-based pre-operative plan. These sizes were compared with the actually implanted sizes during surgery, and the results were assessed. The data were evaluated using Wilcoxon signed rank tests, and p value set at $<0.05$ for significance.
*Results:* Approximately 72% predicted tibia sizes matched the final implanted sizes whereas 66% femoral implants matched their pre-operative predicted sizes. The difference in the tibial implant size was not statistically significant (p-value $>0.05$). However, the difference in the femoral size was statistically significant (p-value 0.009). The downsizing of the tibial component was needed in 14.8% knees whereas upsizing was required in 13.6% of the knees. At the femoral side, 22.7% components required downsizing at the time of implantation as compared to 11.4% components wherein a bigger component was used.
*Conclusions:* We conclude that size prediction using CT-based technology for patient specific instrumentation is not fool proof. The size prediction accuracy for femoral and tibial components at 66% and 72% are low and cannot be relied upon at present. The patient specific technology using CT scan based jigs holds promise for the future, needs refining and fine tuning.



## 1. Introduction

Recently, the number of TKAs being performed worldwide is on the rise. These surgeries are conducted on a regular basis by the specialist arthroplasty surgeons. The customized jigs were introduced to mainly improve the mechanical alignment and hence the overall satisfaction rates post surgery. The customized jig technique works on the premise that the surgeon is able to plan the surgery virtually and is able to predict the outcomes of his proposed femoral and tibial cuts. Prior templating, as done in customized jigs, becomes more important as it also helps in determining the use of non- standard implant, and anticipation of intraoperative deviations from the usual steps.[1,2] Customized jigs not only offer the advantage of the pre-operative planning for the surgery but also offer several other advantages over conventional instrumentation like reduced surgical time, decreased blood loss, efficient operating room management.[3–6] Another less known potential advantage of using customized jigs is the possibility of prediction of implant size to be used during the surgery.

Previously pre operative templating using digital and analog techniques were used for size determination in a conventional TKA.[1–3,7] There are studies to determine the accuracy of templating, using analog and digital radiographs, in the primary hip and knee arthroplasty surgery. However, these studies show variations in the size predicted, and the sizes used and have used radiographs for templating.[7,8] We undertook this study to assess the accuracy of prediction of implant sizes using customized jigs prepared using patient's preoperative CT scan. We hypothesized that the femoral, as well as tibial size prediction using the CT based customized blocks, was accurate.

## 2. Materials and methods

The study included 88 knees in 58 patients (39 females and 19 males) who had undergone TKA using Computed Tomography (CT)

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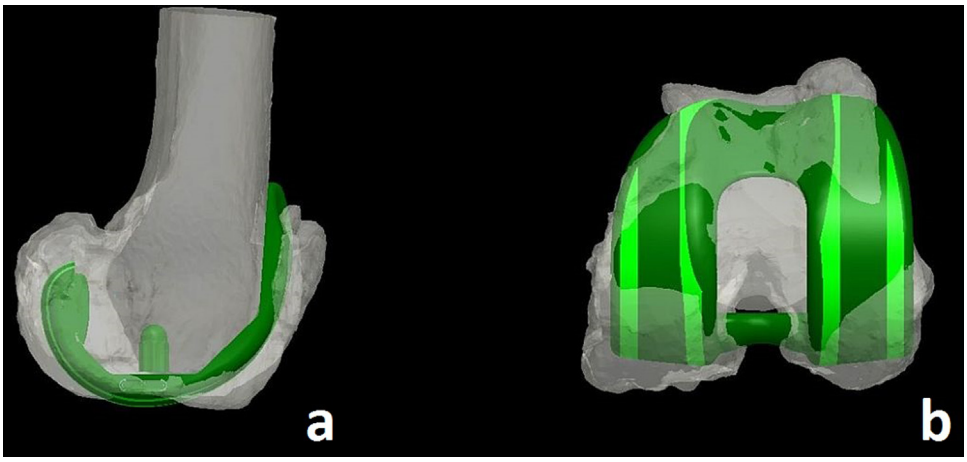


**Fig. 1.** Antero-posterior (AP) and medio-lateral (ML) pre-operative templating of the femur on 3D reconstructed model. Fig. 1a represents the AP templating of the femur and matching the size to avoid anterior notching and match the posterior proposed cut. Fig. 1b represents ML templating of the femur to avoid any medial overhang.

based customized jigs (Preplan ™, Stryker) between March 2015 to April 2016. Out of a total of 58 patients, 30 patients underwent simultaneous bilateral TKA, and the remaining 28 cases underwent unilateral TKA. All the patients were explained regarding the procedure of CT scan, preoperative planning and the use of customized blocks. After a written informed consent, these patients were included in the survey. These patients were informed about the patient specific instruments, its possible advantages and disadvantages over the conventional method. Of these 88 cases, 21 cases had a history of replacement done on the opposite side using the conventional technique. None of the patients had any surgical intervention done on the knee which was included in the present study.

All the patients underwent cemented TKA using CT-based customized jigs (Scorpio Non-Restricted Geometry, NRG™, Stryker). The senior author performed all of the surgeries using the modified Insall exposure of the knee. Custom jigs were prepared in the research and development laboratory of a single company (Preplan ™, Stryker). All the patients had undergone preoperative CT scans from the hip, knee to the ankle (HKA), which is according to the preoperative planning protocol. The CT scan was run on Toshiba CT Acquilion Prime 160 slice machine. The bone cuts were done at 3 mm at the hip and ankle. The CT scans were done at 1 mm increment at the knee and at 3 mm increase at the hip and ankle. The field of view at all the sites was kept as 30–35 cm. Particular care was taken while performing the CT scan to avoid any movement of the patient as any movement while the CT scan was being done would lead to the erroneous calculation of the mechanical axis. The studies of the CT scans of each patient were then sent to the jig manufacturing unit, where they used this information to construct a 3-D model of the arthritic knee. This was done using specially made software which analyses the anatomical landmarks and the surgeon's opinion regarding the rotation, alignment and the extra femoral resection that is needed, keeping in mind the preoperative flexion contracture if any. The design of the customized jigs was based on the mechanical axis and preoperative osteophytes so as to obtain a well-fitting jig. The software was also used to predict the sizes of femoral and tibial components based on the preoperative CT scan. Following this pre operative templating plan was forwarded to the operating surgeon.

The results of the postoperative limb alignment were also assessed, and the mean postoperative MFT angle measured on long-leg radiographs was 178.23° (SD = 2.67°, range: 176.9° to 182.5°).[9]

The CT scan images were also used to match the sizes of the component on the 3D reconstructed images of the femur and tibia, and the most likely size which would be implanted was also proposed (Figs. 1 and 2).

The ideal size of the components for the femur was decided after aligning along the trans-epicondylar axis and measuring the posterior femoral cut. As the thickness of the femoral component is 8 mm, the ideal component size was chosen which gave an 8 mm cut of the posterior condyles. This size was again counter-checked for notching and medial overhang (overhang should not be more than 2 mm). The ideal femoral size which gave 8 mm posterior cut, avoided anterior notching and gave minimum medial and lateral overhang was chosen. At the tibial side, the AP axis was defined from the posterior cruciate ligament footprint and the medial third of the tibial tuberosity. The ideal implant was calculated which minimized the component overhang while providing maximum bony coverage on the tibia. The tibial component was again counter checked for compatibility with the femoral component. After the decision for the bone cuts and the predicted sizes was made, the pre-operative plan was sent to the primary surgeon for approval.

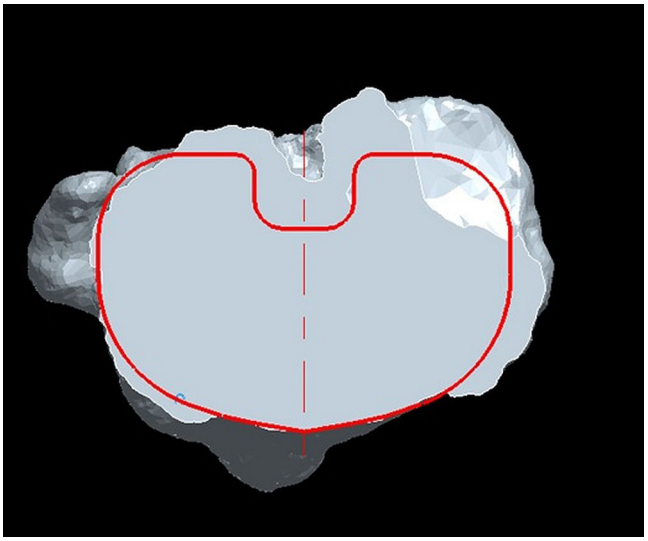

**Fig. 2.** Sagittal pre-operative templating of the tibia on 3D reconstructed model and matching the tibial cut surface anatomy and adjusting the base plate based on the medial one-third of the tibial tuberosity and the PCL footprint.

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