ORIGINAL RESEARCH

Comparison of Tibial Component Alignment in Computer Assisted Navigation Versus Jig based Total Knee Replacement

Adnan Zahoor[1], Jai Thilak M.S.[2], Shaafiya Ashraf[3], Mukesh Kumar[4]

ABSTRACT

Introduction: Malalignment of prosthesis can compromise the clinical outcome. This is a prospectively designed comparative study of CAS with the conventional jig based ones. Here we measured the efficacy of CAS in reducing the outliers (i.e. from the accepted 3 degrees range) of tibial component alignment by comparing the Varus - valgus angles radiologically.

Material and Methods: We studied a total of 150 knees divided into two cohorts of 75 each operated in our institute. The treatment selection was random and a single surgeon performed most of the surgeries. Tibial tray alignment relative to the long axis of the tibial shaft was measured in the coronal plane in postoperative CT scanograms and/or radiographs. The target coronal alignment was 90° with respect to the tibial shaft axis. A total of 75 antero posterior radiographs and 75 CT scanograms were analyzed.

Results: The mean coronal alignment of the tibial component was 88.72° with a standard deviation of 2.36° in Jig based group and 89.45° ± 1.98° with CAS. Although the mean coronal alignment was not significantly different, the number of outliers was substantially reduced in the CAS group with a statistically significant data. In this study we also made an additional observation of having a better alignment of the femoral anatomic axis with the mechanical axis of the lower limb but needs further statistical confirmation.

Conclusions: Computer-assisted total knee replacement improves the frontal alignment of the tibial component in the coronal plane, and thus, increases the longevity and durability of the joint to improve the long and short-term clinical outcome.

Keywords: CAS – Computer assisted surgery, tibial component, joint

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INTRODUCTION

The outcome of knee arthroplasty is affected by component alignment. The tibial component alignment in coronal plane is very important and determining in the weight bearing pattern and determination of the mechanical axis of the lower limb post operatively. The outliers representing >3° of varus or valgus alignment with respect to the anatomic tibial shaft axis do not have long term satisfying results. There are different methods developed by many people to reduce this difficulty, the latest being the computer assisted navigation system.

In this prospectively designed study we compared CAS with the conventional jig based TKRs. We measured the efficacy of CAS in reducing the outliers in tibial component alignment by comparing the Varus/ valgus angles in jig based Vs the CAS.

Over the past few decades, the surgical instrumentation and implant designs used for total knee arthroplasty have undergone a series of improvements.

Malalignment of the prosthesis can compromise the clinical outcome.[1,2]

Malalignment of the prosthesis may lead to deleterious stresses on implanted components and to increased wear rates,[3,4] which are reflected in poor short-term and long-term results and in higher failure rates.[1,5-7]

Surgical preparation of the proximal part of the tibia is typically done with use of an oscillating saw guided by a cutting block, which is in turn positioned with the help of intramedullary or extramedullary alignment instruments or Jigs. Errors in surgical preparation for the bone cuts can occur as deviation of the surface from the desired alignment or as deviation from a flat plane. A mean deviation of 1° (maximum, 4.1°) in the coronal plane has been recorded between the position of the cutting block and the resulting bone cut.[8,9] The concerns regarding deviations in alignment and the "flatness" of the tibial cut, made us to compare the Jig based with the CAS, although we still are in the learning curve of the navigation assisted surgeries. Therefore, the purpose of the present study is to evaluate the efficacy of this device in achieving these goals.

MATERIAL AND METHODS

A total of 150 total knee replacements were evaluated. One cohort (75 knees), we selected from the Jig based traditional method TKRs. In the second cohort (75 knees), we selected from the CAS or Navigation assisted TKRs in which all the cuts were made based on the three-dimensional picture depicted. First 75 all were done Jig based and next 75 all CAS. Single surgeon performed all of the surgeries after proper informed consent.

Tibial tray alignment relative to the long axis of the tibial shaft was measured in the coronal plane in postoperative radiographs and/or in CT scanograms. The target coronal alignment was 90° with respect to the tibial shaft axis (with <90° denoting varus alignment). A total of 90 antero posterior radiographs and 60 CT scanograms were analyzed.

On the anteroposterior radiograph, a line joining the center of the proximal tibial cut and the center of the body of the talus defined the axis of the tibial shaft (Fig. 1). A second line was drawn parallel to the undersurface of the tibial component. The medial angle formed between these two lines was measured to yield the coronal alignment of the tibial component. A coronal alignment angle was measured against the target alignment of 90°. An angle of <90° was classified as varus alignment of the component, whereas an angle of >90° was classified as valgus alignment. All measurements were made manually on radiographs by two independent observers (S.S. and J.T.). The mean of two measurements was recorded for each radiograph. In ~20% of the radiographs that were measured, there was a disagreement of ≤1.° and in ~10% there was a disagreement of < 0.5°

RESULTS

Jig Based: Average angle from tibial axis- 88.68
Std deviation - 2.37
CAS Based: Average angle from tibial axis-89.59
Std Deviation – 1.91
p-value – 0.99 and z-value 2.5891 was calculated applying Student t-test.

Number of outliers was substantially reduced in the CAS group with 15 in Jig based surgeries and only 5 in Computer Assisted Navigation making it statistically significant difference with P value – 0.0353 applying Chi Square Test.

Additional observation was made that CAS gives better alignment of the femoral anatomic axis with the mechanical axis of the lower limb. However it needs further statistical confirmation.

However, a recent study validated similar radiographic measurements, with a mean difference of only 0.9° between radiographic measurement and computerized tomographic scanograms.

DISCUSSION

Computer-assisted surgical devices, image-guided instru-

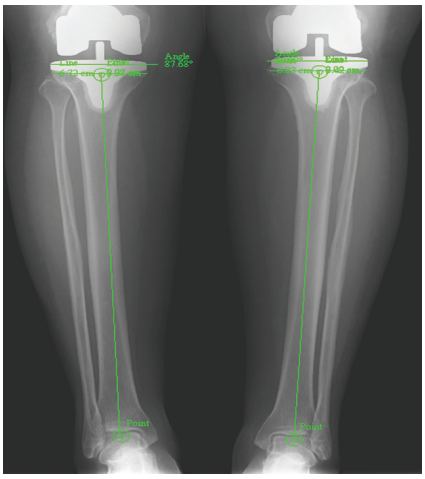

Figure-1: Tibial tray alignment with tibial shaft axis measured in the coronal plane in postoperative radiographs.

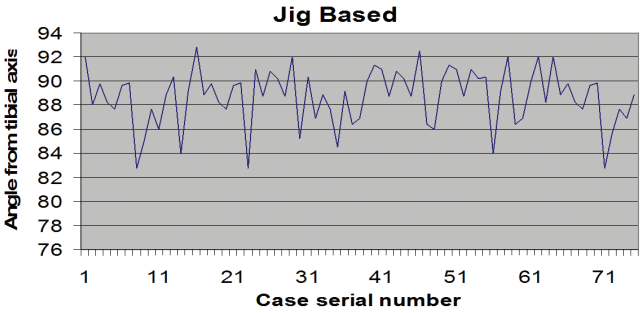

Figure-2: Graphic depiction of the values of the tibial coronal angle in Jig based bone cuts. Area in between two horizontal blue lines falls in the acceptable zone and the rest are the outliers.

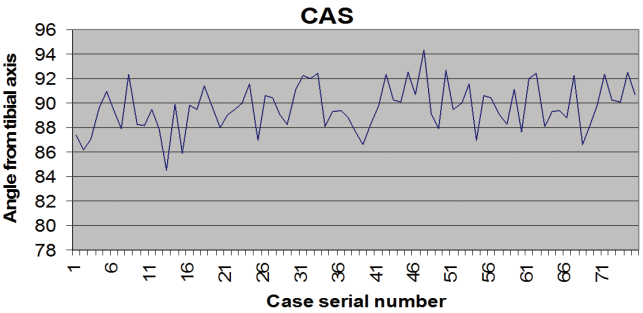

Figure-3: Graphic depiction of the values of the tibial coronal angle in CAS bone cuts. Area in between two horizontal blue lines falls in the acceptable zone and the rest are the outliers.

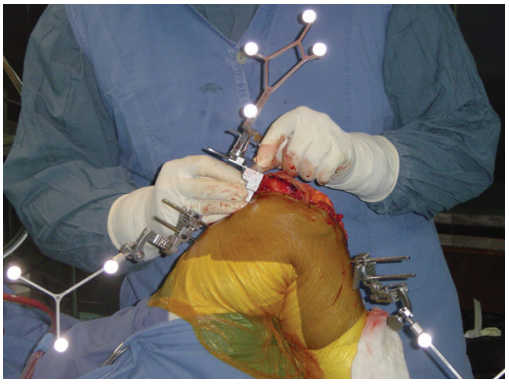

Figure-4: Perioperative picture showing the navigation CAS.

ments, and active robotic surgery have been proposed to reduce alignment errors and to increase the accuracy and precision of the femoral and tibial cuts.[11-14] Several studies have demonstrated that computer-assisted surgical navigation increases the accuracy of component alignment relative to conventional surgical instrumentation and reduces outliers in alignment.[15-20]

Malalignment of the tibial component alters the distribution of tibial loading and can increase shear forces at the tibiofemoral interface, resulting in increased wear. Several studies have demonstrated that varus tibiofemoral malalignment results in increased wear and a high failure rate.[4,21-25] A threshold of 3° of varus malalignment has been reported to significantly increase the risk of medial bone collapse (hazard ratio = 17.2, $p < 0.0001$).[26]

In the present study, although the mean tibial alignment was better in Jig based TKRs and 100% of the tibial trays in the group that was treated with use of the CAS were not within 3° of neutral alignment we still got a comparable result of within 1° range in average tibial angle. These findings suggest that our initial CAS results are comparable to the traditional Jig based TKR alignment and with further experience in CAS we hope to reduce the chances of coronal malalignment and thus reduce the potential risk of implant failure.

Currently, computer-navigation systems are expensive, involve a considerable learning curve, and usually add to the overall operative time, all of which generate resistance to their universal acceptance. Developments are under way to reduce the cost and improve the efficiency of these navigation systems.

Computer-navigation systems also have the advantage of improving femoral and overall limb alignment in addition to tibial alignment.

CONCLUSION

In both Jig based and CAS methods of total knee replacements overall results are within the accepted range of 3 degrees. However the outliers being more in the Jig based as compared to CAS. These outliers can be significantly reduced with an additional useful tool in surgeons hand in the form of – Navigation.

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