Research Article

Evaluation of results of total knee replacement by computer assisted navigation and conventional techniques

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Abstract

Introduction: Accurate component implantation and eventually the overall limb alignment are the essential requirements of a successful knee arthroplasty. Computer assisted navigation came into vogue with a claim of precision in aligning the limb as compared with the conventional jig based technique. This retrospective study evaluates the results of fifteen cases of total knee arthroplasty performed by the conventional technique and five cases, by the computer assisted navigation. **Methods:** This retrospective study was carried out at Ayushman hospital and Chirayu medical college, Bhopal from1993 to 2014. All patients selected, were suffering from tri -compartmental osteoarthritis of the knees having severe pain and varus deformity, except one who had post traumatic secondary osteoarthritis.. In fifteen cases total knee arthroplasty was done by using the jig based conventional technique whereas computer assisted navigation was used in five cases. **Results:** Intraoperatively less blood loss and a comparatively comfortable immediate post operative period were observed. However there was no appreciable advantage noticed in the long term results. **Conclusion:** Computer navigation by virtue of its feedback on screen during the surgery helped, to improve the accuracy of aligning the mechanical axis, whereas in the conventional jig based surgery, dependence was entirely on visual perception of the angles and cuts.

Key words: Computer navigation, Alignment.

Introduction

The first computer assisted surgery in orthopaedics, was done by W. Barger, in 1992 at Sacramento, California for total hip replacement, while the first total knee replacement was begun by F. Picard and D. Saragaglia in France in January 1997 after a study on cadavers and later compared their prospective study of CAS to the conventional surgery in 50 patients [1 2].

Total knee arthroplasty has evolved to be a promising and a reliable procedure with better implant survival rates. Proper patient selection, surgical technique, implant design and patient participation in the rehabilitation protocol help to achieve the goal of pain relief and better knee function [3].

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Technical excellence demands proper correction of deformities, soft tissue balancing and an accurate alignment in the frontal, saggital and horizontal planes. To fulfil these criteria the conventional techniques of surgery use intramedullary and

extramedullary jigs to guide the necessary cuts made on distal femur and proximal tibia for proper fixation of the implants. Proper alignment in the frontal plane, within 2 to 3 degrees of the neutral alignment is of vital importance. It has been observed that a prosthesis implanted in a neutral or valgus position has a better survival rate than one implanted in a varus position.[4] Also the mechanical axis aligned within 2 to 3 degrees results in 3% loosening whereas beyond that, has a loosening rate of 24% [5]. Mal alignment in the horizontal plane with extensor mechanism problems may have internal rotation of the tibial and femoral components [6].

Hence it is of vital importance that the post operative mechanical axis passes from the centre of the head of the femur, to the centre of the knee and the centre of the ankle, so that it lies within 3 degrees of the neutral axis. Since long term durability depends upon accuracy of implant positioning [5,7] , visual accuracy with mechanical jigs necessitated precision. A well-aligned hip or knee replacement is less likely to dislocate and may last longer.[8, 9]. Chin, Coventry, Decking and Lotke opine that computer assisted surgery results in better overall limb and implant alignment and fewer outliers as compared to findings after manual total knee arthroplasty.[10, 11, 12, 13]. Computer assisted navigation itself is a promising technology which has already improved the alignment of knee arthroplasty. [14,15,16].

Computer assisted surgery thus found its way and entered the scene of knee arthroplasty with all its intricacies, benefits and enigmas.

Material and Methods

This retrospective study was carried out on cases operated at Ayushman hospital and Chirayu medical college, Bhopal from1993 to 2014. All the patients selected for this study were suffering from tri - compartmental osteoarthritis of the knees. Almost all the patients had severe pain and varus deformity, in the knees to be operated and had undergone prolonged conservative treatment for the same. One patient had an old untreated fracture of the medial femoral condyle with painful osteoarthritis and varus deformity of the knee. In fifteen cases total knee arthroplasty was done by using the jig based conventional technique whereas computer assisted navigation was used in five cases. The components used were of different companies namely, Depuy, Stryker and Inor. The navigation machines were provided by Stryker and Depuy. The mean age of the patients was 65.1 years, ranging from 52 to 78 years.

Preoperative Preparations: The essential requirements prior to surgery included skiagrams in antero-posterior, lateral and 30 degrees flexion views of both knees in a standing, weight bearing position to correctly assess the narrowing of the joint space. The patients were counselled and taught full range of motion and muscle strengthening exercises preoperatively which they had to pursue after surgery.

The details of the patients who were treated by the conventional technique are not being discussed here. The computer assisted navigation system essentially involves three main elements viz. the computer intelligence, the tracking system and the body markers. The body markers were rigidly applied to femur and tibia with bicortical fixation. Any movement of the bones fixed with markers triangulate with the tracking cameras with the help of infra red lights emitted by them. This information is then interpreted by the computer which determines the position of each marker. The computer does not detect bone. Markers attached to the cutting block instruments are also tracked. This facilitates the dynamic referencing base when targeting the surgical instruments or implants.

The tracking system consists of an optical camera (Fig.1), electromagnetic coil to pick up the infrared light, electromagnetic pulses, or ultrasonic waves which originate from the trackers (Fig.2). Referencing of the target objects was then done. It helps to define the points in virtual space with the help of a pointer probe (Fig.3) that can be triangulated by a tracking system obtaining the x,y,z coordinates(Fig.4) of each marker. The computer then calculates the three dimensional position of the trackers.

Fig.1

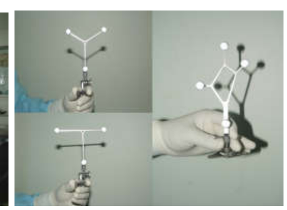

Fig.2

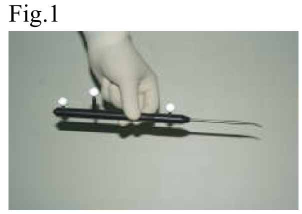

Fig.3

Fig.4

Optical Camera The trackers The pointer probe The 3D images

Registration of the three dimensional data is of utmost importance for image free navigation. Computer registration of femur involves rotating the femur in a loose arc, while the the soft ware registers various points to determine the centre of rotation of the femoral head. This determines the most proximal point of the mechanical axis of the limb. The hip centre was registered by the circular kinematic movements of the hip. The distal femoral centre was registered as the point under the roof of the intercondylar notch and lies on the transepicondylar and the anteroposterior axis of Whiteside. On the medial side the surgical depression was the reference for the medial epicondyle and the lateral most prominent point was registered as the lateral epicondyle. The tibial reference includes the transverse tibial axis which connects the anteroposterior midpoints Key landmarks are registered by pivoting a pointer at specific anatomical landmarks like the malleoli (medial and lateral), mechanical axis (proximal tibia and distal femur), the proximal tibial contour (medial,lateral and anterior), the femoral epicondyles (medial and lateral) and the femoral anterior sizing point.

The tibial AP direction and the Whiteside's line were acquired by holding the pointer still in a specific direction. The bone areas to be resected are registered by pivoting the pointer tip and sliding the pointer along the bone structures . The following are registered in this way: The tibial plateau, the femoral condyles medial and lateral and the anterior cortex tibia and femur.. The most important step is the registration of the anatomical landmarks around the knee which, if not done judiciously may lead to errors of the medial and lateral condylar surfaces and should approximate the transepicondylar axis for coupled rotation. The centre of the proximal tibia is the bisection of the centre of the transverse and the anteroposterior axis of the proximal tibia.



Fig.5 Fig.6 Fig.7

Trackers in position Femoral Jig.

The centre of the ankle is registered by digitizing the lateral and medial malleoli and picking up a point on the transmalleolar axis which is 40 % from the most medial point. Validation of the check points is necessary throughout the procedure. Once patient registration is complete, the computer softwear provides the surgeon with valuable information including the angles, lines and measurements of the patient"s unique anatomy and displays the exact location of the instruments in relation to the knee joint (Figs.5,6,7).. The bony cuts of tibia and femur including the chamfer cuts etc. were made according to the information furnished by the computer and the ligament balancing was done by assessing and correcting the valgus or varus deformities shown by the computer. The coronal and sagittal alignment of the components were assessed after cementing. Navigated cases showed a comparative degree of less bleeding during surgery.The wound was closed in layers and a drain was inserted in all cases which was removed on the second day of surgery. A compression bandage was applied.

After treatment consisted of continuous passive motion exercises in bed from full extension to thirty degrees of flexion to start with immediately after the patient was shifted to the ward which was gradually increased as the tolerance of the patient increased. Quadriceps setting exercises were instituted on the first day post operatively. The patients were allowed to sit on the side of the bed with their limbs hanging when they achieved approximately sixty degrees of knee flexion. They were allowed to stand and bear weight only after they gained full control of the limb as assessed by the straight leg raising test. Climbing stairs was encouraged after regaining sufficient muscular strength. Regular quadriceps and hamstring exercises were advised after discharge from the hospital.

Results

All cases had an uneventful recovery. Out of the fifteen cases operated by the conventional technique two cases died after nine and twelve years of surgery The longest follow up in this group has been for fourteen years and the shortest for three years. All the patients could fully bear weight without support. The range of movements varied from full extension without any extensor lag to 130 to 140 degrees of flexion. .We did not come across any cases of thromboembolism, infection or iatrogenic fractures. One patient had to undergo a revision surgery for an aseptic loosening of the tibial component three and a half years after surgery. A revised tibial component with an extension rod had to be inserted. Five cases operated by the navigation technique showed a strikingly comfortable post operative recovery. They regained their range of movement earlier than the conventional group. However there was not much difference in the long term results of the two groups.

Discussion

Superior alignment had been shown in the coronal, sagittal and rotational planes as shown by early single – centre studies of computer navigated total knee replacements.[17,18] A cause of premature implant failure may be the malalignment in the coronal plane of more than three degrees.[19,20,21] However Kim et al,[22] in bilateral tkr with one knee navigated and the other done traditionally found that the alignment and orientation were not different. In our series, in one female aged sixty eight years who had bilateral tkr with one knee navigated and the other done conventionally we found that the only difference was that the navigated knee had a comparatively more comfortable immediate post operative period than the other with earlier recovery of the range of movements. A twelve percent reduction in the contact stresses on the polyethylene tibial insert was also shown in a seies which logically would enhance component longevity.[23]We encountered only one case of tibial component loosening after three and a half years of the initial surgery which was from the conventionally done tkr group.

Computer assisted knee arthroplasty, in this study benefitted the patients with a restoration of the mechanical axis,within three degrees, improved component implantation, less blood loss and a comparatively comfortable immediate post operative period as compared to the patients operated by the conventional technique. Computer navigation by virtue of its feedback on screen during the surgery helped, to improve the accuracy of aligning the mechanical axis, whereas in the conventional jig based surgery, dependence was entirely on visual perception of the angles and cuts. There was no appreciable advantage noticed in the long term of patients operated by computer navigation over the conventional technique.

However the advantage or the difference between the two techniques of navigation and conventional tkr is smaller than it was expected earlier [24].

Conclusion

Cost benefit ratio and the learning curve of surgeons are important factors to be considered. Further improvement in the navigational technology involving ligament balancing and kinematics may enhance the use of CAS as compared to little scope of improvisations in the manual jig based armamentarium. Restoration of the alignment to within three degrees may be a contributory factor in the proper patellar movement and affording a comfortable immediate post operative recovery period which we experienced in our group of navigated knees.

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