Science Letters ISSN 2345-5463 – An International Triannually Journal

THE SCIENCE PUBLISHERS

Research article
2018 | Volume 6 | Issue 2 | Pages 46-53

Open Access

An Experimental Study of iAssist Total Knee Arthroplasty Technique

Vanniar Senthur Rajendren, Cheng Yu Huang, Mujtaba Ansari, Umair Masood, Li Ming Wang*

Nanjing First Hospital (Affiliated Hospital of Nanjing Medical University), Han Zhong Road, Nanjing Medical University, 210021, Nanjing, Jiangsu, China

Abstract

Zimmer® iAssist is an accelerometer and gyroscope-based system, which is as accurate as computer-assisted systems and other optical navigation systems in achieving a neutral mechanical axis. It has better functional outcomes when compared with conventional systems. In this paper, we experimented on a 3D printed model to determine the accuracy of the iAssist system and also checked how the system responded in determining the mechanical axis when the guides were not positioned properly. In our experiment, the iAssist system produced acceptable and consistent results when its guides were positioned properly and when it was improperly positioned, the results were more skewed, which would result in valgus or varus deformity depending on the position of the guide. The iAssist system depends on the surgeon to input accurate data and proper positioning of the guides to acquire the correct mechanical axis of the knee. Even though it's not perfect, it is definitely a step in the correct direction to achieve higher accuracy associated with computer-assisted systems with the familiarity associated with conventional systems.

ARTICLE INFO

Received
March 25, 2018
Accepted
June 05, 2018
Published
August 10, 2018

***Corresponding Author**
Li Ming Wang
E-mail
wangliminqnj@gmail.com
Phone
+86 18951670968

Keywords
iAssist
Navigated TKA
Conventional TKA
Knee mechanical axis

How to Cite
Rajendren VS, Huang CY, Ansari M, Masood U, Wang LM. An experimental study on iAssist total knee arthroplasty technique. Sci Lett 2018; 6(2):46-53

Note

First and second author contributed equally to this manuscript.

Scan QR code to see this publication on your mobile device.

Introduction

Total knee arthroplasty is being performed in large numbers every year and the number of replacements done keeps on increasing year by year. This puts the pressure on the joint replacement surgeons to get the desired results in the first attempt [1]. Arthritis, especially osteoarthritis is the most important cause of joint pain and in spite of various treatments available, total knee replacements remain the best and effective treatment for treating and improving the quality of life for those suffering from osteoarthritis. The success of every total knee arthroplasty depends on various factors like component positioning, component alignment, flexion and extension gaps and the balance of soft tissue achieved [2-6]. As proved by many previous studies that an accurate implanted component and the mechanical axis of ±3° to the neutral mechanical axis leads to long-term prosthesis survival and decreased component loosening [2, 7-13].

Berend et al. [14] in a review of 3152 total knee arthroplasties proved that the chance of implant failure was greater by about 17 times just because of tibial varus alignment of greater than 3°. Jeffry et al. [9] in an analysis of 115 people found implant loosening in 24% of cases when valgus and/or varus deformity exceeded 3° to the neutral mechanical axis, but it was only 3% in other cases. Richard et al. [15] in their study of people under 65 years of age and underwent total knee arthroplasty got a significant difference in the revision rate in favor of those who underwent navigated total knee arthroplasty versus those who underwent conventional knee arthroplasties. While performing total knee arthroplasty, the operating surgeon aims to achieve a position close to the neutral mechanical axis [16]. The more conventional method of using intramedullary and extramedullary jigs to achieve the cuts have a limited degree of accuracy to achieve correct component placement and mechanical axis restoration to be as close to the neutral mechanical axis as possible. Several studies have confirmed this irrespective of the surgeon's experience [17 23]. Errors can happen as this technique is dependent on the surgeon’s judgment, fixation of instruments, knowledge of knee kinematics and hand-eye coordination [23-25]. Mahaluxmivala et al. [26] in an analysis of 673 total knee arthroplasties found varus and /or valgus alignment of more than 3 degrees with the neutral mechanical axis irrespective of the surgeon's experience.

Many published papers show computer-assisted surgery to be superior in achieving the desired results when compared to conventional systems [27-30]. Mason et al. [23] in their study showed that 65.9% achieved perpendicular femoral varus and/or valgus alignment within 2° and 79.7% achieved tibial varus and/or valgus alignment 2° perpendicular to the tibial mechanical axis in the conventional group while in the computer-assisted surgery group those were achieved by 90.4% and 95.2%, respectively. In a recent study, it was shown that iAssist system had fewer outliers in low limb alignment [31]. Matthew et al. [32] in their study got a malalignment of ≥3° in 4% of cases who underwent iAssist surgery compared to 36% in the conventional group. They also showed iAssist had significant improvement in the variances of both femoral and tibial mechanical axis. However, despite promising results, computer-assisted surgery still failed to penetrate more than 5%. It may be due to the sensitivity of the instruments, increased capital costs, the complexity of use, longer operation time and an obvious learning curve associated with any new technique. Some studies have reported cases of fractures arising due to the additional placement of pins [20, 33-40].

Recently, navigation systems have been developed using accelerometer and gyroscopes like iAssist systems in an attempt to combine the accuracy associated with large console computer-assisted systems and convenience of conventional systems without the need for large computers to assist in recording and provide the alignment results to the surgeon intra-operatively [18, 41]. In a study, Dessaux et al. [42] showed iAssist system had similar results in the restoration of hip knee angle, component positioning, and optimal success compared to other optical navigation systems. In addition, they showed that iAssist achieved 95% cases with a neutral mechanical axis and optimal component positioning. The iAssist (Zimmer Inc, Warsaw, IN) system uses four pods, which house gyroscopes and accelerometers that are attached to the surgical instruments, and intra-operatively, it provides the precise alignment and position in relation to anatomic landmarks. All the information from the pods is sent to a screen placed near the operating table in the line of sight of the surgeon using a secure Wi-Fi network. The data displayed on the screen is also verified by the flashing green

and red lights on the pods themselves. Green lights indicate the jigs are positioned within an acceptable range, whereas red light signals the alignment is not according to the accepted values and have to reposition the jigs accordingly [2].
All surgeries are to be performed under tourniquet with medial patellar approach and femur first technique using the intramedullary 7.9 mm spike guide. Ideally, the starting point is slightly medial and posterior to the center of the notch between both epicondyles [2, 12]. To establish the mechanical axis, the femur is first prepared with an intramedullary guide. A 7.9 mm spike is impacted in the Whiteside's line (Fig 1A) [43]. After aligning the femoral reference guide on the spike and leg placed in a neutral position, 13 stable positions are acquired by accelerating and stopping the leg creating a star-shaped pattern. Audio feedback from the system confirms the acquiring of each stable position. After completing the step of acquiring positions, the resection guide is fixed to the reference guide the femoral valgus and/or varus and flexion and/or extension are set as per preoperative goals. Led lights on the pods indicate the exact degree and it can be set by turning the two knobs which change the alignment of the resection guide accordingly and the degrees are confirmed on the screen as well. After securing, the femoral adjustment mechanism with screws the distal femur is resected. Following the bone resection, the cuts made are confirmed using a validation tool secured with captive spikes and the values of valgus/varus and flexion /extension are displayed on the screen. Adjustments can be made if necessary and further cuts are made using the chosen implant.

The tibia is prepared by an extramedullary guide. After positioning the tibial alignment guide to left on right leg accordingly, the guide is installed on the ankle by gripping the distal clamps around the malleoli similar to conventional guides. The longer mechanical axis digitizer spike is partially inserted in the highest point of the center of the tibial plateau and after orienting the guide with the medial third of the tubercle, the guide spike is further impacted to align it to the patient mechanical axis. The tibial resection guide is placed to the tibial tuberosity after fixing it with three screws, the bone reference is attained by positioning the leg in abduction, adduction and neutral position. After removal of the digitizer, the tibial varus and/or valgus and posterior slope are set according to preoperative goals. The degrees can be changed with the help of two knobs similar to femoral resection guide. The depth of tibial cut is determined using the tibial stylus. The cuts are validated with a validation tool and further resection can be done if required. After checking the joint space and range of motion using trial components and spacers, the tibial component is inserted followed by femoral component insertion and then finally inserting the polyethylene component similar to the conventional technique. Care is taken to avoid femoral component flexion during the insertion.

Materials and methods

We conducted a simple experiment in our hospital lab with the help of 3D printed model of the knee. We followed the iAssist protocol to achieve the normal neutral mechanical axis in our 3D printed model (Fig. 1A-1F). For the femoral resection guide, we set the valgus and varus at 0 degrees and flexion and extension at 3 degrees. For the tibial resection guide, we set the varus and valgus at 0 degrees and the posterior slope at 7 degrees. After achieving the results, we recorded the site of impaction of the bone saw on the surface of the femur and tibia respectively, and later we changed the orientation of the 7.9 mm spike directed towards the lateral position of the femur, instead of normal axis and we carried out the 13-step process for acquiring the mechanical axis of the femur. We recorded the various angles of offset while getting the femoral cuts. Similarly, for the tibial alignment guide, we impacted the digitizer spike on the lateral condyle of tibial plateau rather than the highest point on the center of the tibial plateau and recorded the angles where we would get the cut of the bone saw (Fig 2).

Results

In our experiment, when 7.9 mm spike was spiked orienting towards the lateral part of the femur, the angle of resection was skewed, which would result in more resection of the medial surface compared to the lateral surface of the femur and it would result in a varus knee postoperatively (Fig 3). Similarly, when the orientation of the spike would change to the medical side, it would have similar results, but on the opposite side resecting more of the lateral surface than the medial resulting in varus alignment. When we impacted the digitizer spike on the lateral surface of the tibial plateau instead of the highest point of the center of the tibial plateau, we got the angle skewed with resecting more part of the lateral condyle than the medical part (Fig 4). This would

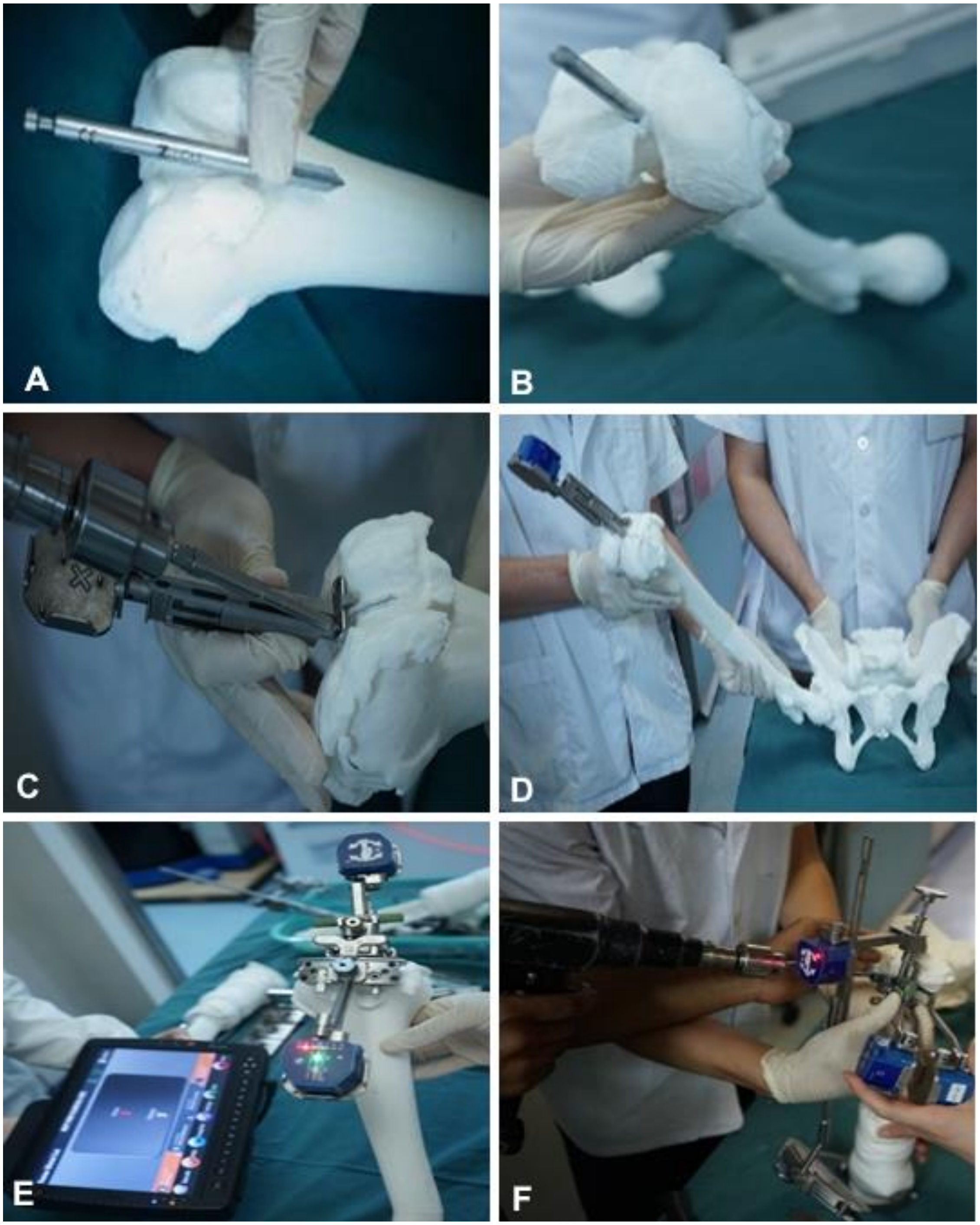

Fig. 1 The orientation and depth of impaction of the 7.9 mm spike impaction on the femoral section of the 3D printed model (A), correct positioning after impaction of the 7.9 mm spike on the Whiteside's line (B), fixation of femoral resection guide with screws (C), acquiring of 13 stable positions via accelerating and stopping the knee creating a star-shaped pattern after fixing the iAssist pod to the femur resection guide (D), setting of degrees of valgus or varus and flexion or extension gaps on the femoral resection guide according to our pre-operative goals (E) and fixation of tibial resection guide (F).

result in more of a varus alignment and similarly if we would have impacted the digitizer on the medial surface, it would result in varus knee as more of the lateral surface would be resected. This is seen due to the alignment error, we feed, the system does not take human error into account and it recognizes the knee to be very bowed. It compensates for the error even when we set the varus and valgus to 0° by

Fig. 2 Placement of the tibial resection guide lateral to the highest point in the center of the tibia.

Fig. 3 The offset of angles of bone cut when 7.9 mm spike is spiked in an angle facing the lateral condyle versus the correct alignment angle. When it 7.9 mm spike is impacted by incorrect orientation, the cuts made are straight and when the spike is oriented laterally then the bone saw cuts more on the medial surface of the femoral condyle.

Fig. 4 The offset in the alignment of the bone cut when the tibial spike was impacted on the lateral surface of the tibial plateau as shown in Fig. 3, versus the correct position of spiking it on the highest point of the tibial plateau. The oblique line is the angle which the bone saw cuts when its spike is impacted laterally and the straight line is the cut, which the bone saw makes when digitizer spike is placed correctly.

achieving an oblique cut.

Discussion

Though the necessity to achieve neutral mechanical axis is challenging, the most common reason for implant failure is imperfect implant positioning, which results in excessive wear of the implant on a particular side if it is not aligned properly as per the design of the implant [43]. In addition, loosening of implants can lead to periprosthetic fractures [11, 14, 45, 46]. Several papers have been published in the past, which mainly focus on long-term results of implant survival of total knee arthroplasty. All concluded that the worst functional outcome was achieved when the implant is maligned by more than 3 degrees in varus or varus axis to the neutral mechanical axis [47-50]. Parratte et al. [51] concluded that achieving a neutral mechanical axis has to be considered a gold standard until more data is collected and accurate postoperative limb alignment is determined for each individual patient. In this experiment conducted, we found that iAssist system is a very good system in determining the neutral mechanical axis provided that the spikes are aligned properly and the proper input is given to the system. In every knee arthroplasty performed, the surgeon achieves a well-balanced knee by achieving a slightly oblique cut in the frontal and sagittal plane, by releasing the soft tissues and equal flexion and extension gaps to get the desired result [12].

In a study conducted by Vanniar et al. [52] showed that tourniquet time for patients in the iAssist group was comparatively higher than conventional group. This was associated with the learning curve associated with learning a new technique to acquiring the 13 stable positions for the femoral registration guide. Sometimes the system is not able to register the points successfully and the procedure has to be repeated until the system registers the points accurately, it is similar for tibial registration as well. But their result was contradictory to that of Nam et al. [53] and Mathey et al. [54] in which they reported less or equal tourniquet time in the navigational group to that of conventional group. Confaloneri et al. [55] in their study proved that superior results were achieved by those surgeons who had experience in computer-assisted surgeries compared to novice surgeons and they had less operative time initially but found no significant difference after 9 surgeries. They set the learning curve in 16 cases, which seems to be acceptable and in spite of all the advantages, there were no significant results in the number of outliers and just after 11 surgeries, there was no significant difference in the number of recuts made. Compared to large console computer-assisted surgery (CAS) systems, iAssist has several advantages like no additional initial costs to set up consoles, avoidance of using additional tracking pins for surface registration, so no additional incisions for the placement of additional pins and hence no complications related to placement of pins. It also eliminates the issue of line of site as reported by Goh et al. [12]. The surgical time in iAssist is significantly lower when compared to large console computer-assisted surgical systems. This can be associated with the degree of familiarity which Zimmer iAssist system pods connect to the instruments similar to those used in conventional systems. The iAssist system uses a 7.9 mm spike impacted into the femur and as there is no need to remove the fat from femur using a cannulated rod like the ones used in conventional systems, it lessens the probability of fat embolism [12, 40, 58]. The most important feature about iAssist which adds to the confidence of the surgeon is its ability to validate the femoral and tibial cuts to the precise degree of accuracy as planned preoperatively and the cuts can be adjusted if necessary. As the bone saw can be flexible and can drift during resection even when the cutting jigs are secured well. Scuderi et al. [2] found that iAssist systems were reliable within 1° to optical navigation systems.

Several limitations about iAssist have to be acknowledged. The system should not be used in cases of hip pathology, which severely limits the range of motion (e.g., arthrodesis, severe contractures, and chronic severe dislocation) or in cases of hip joint pathology or knee pathology with significant bone loss (e.g., avascular necrosis of the femoral head with collapse, severe dysplasia of the femoral head or the acetabulum and femoral condyle collapse) and for total knee arthroplasty using the Quad-Sparing technique. iAssist systems heavily depend on the surgeon to position and input accurate data to determine the mechanical axis as proved in our experiment. If the positioning or the orientation of the femoral or tibial spikes are varied the iAssist system doesn't take it into account as there are no associated imaging techniques like some computer-assisted systems, it does not take into account for variations in anatomy, like a very bowed femur or tibia in the sagittal plane [53]. Also the soft tissue balancing and implant size information is not provided to the surgeon so the size of the implants is determined by sizing jigs as used in conventional systems, thus the surgeon needs to have experience in using the conventional system to correctly determine the size of implant to be used and achieve proper soft tissue balancing for a well-balanced knee [12]. In a study, it was shown that during tibial registration, a pod suddenly got disconnected and attempts to reconnect and recalibrate by the staff was futile and the surgeon had to complete the tibial resection by himself, as in that case, he was an experienced surgeon, so he had no problem in determining the required level and the orientation of the cut required [56]. Confalonieri et al. [57] also proved that a novice surgeon trained in computer-assisted techniques, after a finite number of cases can replicate the results of an experienced surgeon, although experience plays a huge role in recovering and achieving the desired result when occasionally the components fail.

Conclusions

iAssist system depends on the surgeon to input accurate data and proper positioning of the guides to acquire the correct mechanical axis of the knee and even though it's not perfect. It is definitely a step in the correct direction to achieve higher accuracy associated with computer-assisted systems with the familiarity associated with conventional systems.

Conflict of Interest

The authors declare that we have no conflict of interest to declare.

References

[1] Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007; 89(4):780-5.
[2] Scuderi GR. Total knee arthroplasty performed with inertial navigation within the surgical field. Semin Arthroplasty 2014; 25:179-186.
[3] Bugbee WD, Kermanshahi AY, Munro MM, McCauley JC, Copp SN. The accuracy of a hand-held surgical navigation system for tibial resection in total knee arthroplasty. The Knee 2014; 21:1225-1228
[4] Tanikawa H, Tada M, Harato K, Okuma K, Nagura T. Influence of Total Knee Arthroplasty on Patellar Kinematics and Patellofemoral Pressure. J Arthroplasty 2017; 32:280-285.
[5] Goh G, Bin Abd Razak SH, Tan JYW, Yeo SJ. Intraoperative measurements of joint line changes using computer navigation do not correlate with

postoperative radiographic measurements in total knee arthroplasty. J Arthroplasty 2017; 32:61-65.
[6] Nikolopoulos D, Michos I, Safos G, Safos, P. Current surgical strategies for total arthroplasty in valgus knee. World J Orthop 2015; 6:469-482.
[7] Miyasaka T, Kurosaka D, Saito M, Omori T, Ikeda R, Marumo K. Accuracy of computed tomography-based navigation-assisted total knee arthroplasty: outlier analysis. J Arthroplasty 2017; 32:47-52.
[8] Siston RA, Giori NJ, Goodman SB, Delp SL. Surgical navigation for total knee arthroplasty: a perspective. J Biomech 2007; 40:728–735.
[9] Jeffery RS, Morris RW, Denham RA. Coronal alignment after total knee replacement J Bone Joint Surg Br 1991; 73:709–714.
[10] Maniar RN, Johorey AC, Pujary CT, Yadava AN. Margin of error in alignment: a study undertaken when converting from conventional to computer-assisted total knee arthroplasty. J Arthroplasty 2011; 26:82- 87.
[11] Iorio R, Mazza D, Drogo P, Bolle G, Conteduca F, Redler A, et al. Clinical and radiographic outcomes of an accelerometer-based system for the tibial resection in total knee arthroplasty. Int Orthop (SICOT), 2015; 39:461–466.
[12] Goh GSH, Liow MH, Lim, WSR, Tay DKJ, Yeo SJ, Tan MH. Accelerometer-based navigation is as accurate as optical computer navigation in restoring the joint line and mechanical axis after total knee arthroplasty. J Arthroplasty 2016; 31:92–97.
[13] Thiengwittayaporn S, Fusakul Y, Kangkano N, Jarupongprapa C, Charoenphandhu N. Hand-held navigation may improve accuracy in minimally invasive total knee arthroplasty: a prospective randomized controlled trial. Int Orthop 2016; 40:51–57.
[14] Steiger RN, Liu YL, Graves SE. Computer navigation for total knee arthroplasty. J Bone Joint Surg 2015; 97:635-642.
[15] Nam D, Cody EA, Nguyen JT, Figgie MP, Mayman DJ. Extramedullary guides versus portable, accelerometer-based navigation for tibial alignment in total knee arthroplasty: a randomized, controlled trial: winner of the 2013 hap paul award. J Arthroplasty 2014; 29:288–294.
[16] Anderson KC, Buehler KC, Markel DC. Computer assisted navigation in total knee arthroplasty: comparison with conventional methods. J Arthroplasty 2005; 20:132-138.
[17] Gharaibeh MA, Solayar GN, Harris IA, Chen DB, MacDessi SJ. Accelerometer-based, portable navigation (kneealign) vs conventional instrumentation for total knee arthroplasty: a prospective randomized comparative trial. J Arthroplasty 2017; 32:777–782
[18] Anand S, Harrison JW, Buch KA. Extramedullary or intramedullary tibial alignment guides: a randomised, prospective trial of radiological alignment. J Bone Joint Surg Br 2003; 85: 1084-1088.
[19] Anderson KC, Buehler KC, Markel DC. Computer assisted navigation in total knee arthroplasty: comparison with conventional methods. J Arthroplasty 2005; 20:132–138.
[20] Bardakos N, Cil A, Thompson B, et al. Mechanical axis cannot be restored in total knee arthroplasty with a fixed valgus resection angle: a radiographic study. J Arthroplasty 2007; 22:85-89.
[21] Dennis DA, Channer M, Susman MH, et al. Intramedullary versus extramedullary tibial alignment systems in total knee arthroplasty. J Arthroplasty 1993; 8: 43- 47.
[22] Mason JB, Fehring TK, Estok R, Banel D, Fahrbach K. Meta-analysis of alignment outcomes in computer-assisted total knee arthroplasty surgery. J Arthroplasty 2007; 22: 1097–1106.
[23] Bathis H, Perlick L, Tingart M, et al. Alignment in total knee arthroplasty. A comparison of computer assisted surgery with conventional technique. J Bone Joint Surg Br 2004; 86:682–687.
[24] Rosenberger RE, Hoser C, Quirbach S, et al. Improved accuracy of component alignment with the implementation of image free navigation in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2008; 16:249–257.
[25] Mahaluxmivala J, Bankes MJ, Nicolai P, et al. The effect surgeon experience on component positioning in 673 press fit condylar posterior cruciate-sacrificing total knee arthroplasties. J Arthroplasty 2001; 16:635 - 640.
[26] Decking R, Markmann Y, Fuchs J, Puhl W, Scharf HP. Leg axis after computer navigated total knee arthroplasty: a prospective randomised trial comparing computer-navigated and manual implantation. J Arthroplasty 2005; 20:282-288.
[27] Mulhall KJ, Ghomrawi HM, Scully S, Callaghan JJ, Saleh KJ. Current etiologies and modes of failure in total knee arthroplasty revision. Clinical Orthop Rel Res 2006; 446:45–50.
[28] Blakeney WG, Khan RJ, Wall SJ. Computer-assisted techniques versus conventional guides for component alignment in total knee arthroplasty: a randomized controlled trial. J Bone Joint Surg Br 2011; 93:1377–1384.
[29] Barrett WP, Mason JB, Moskal JT, Dalury DF, Oliashirazi A, Fisher DA. Comparison of radiographic alignment of imageless computer-assisted surgery vs conventional instrumentation in primary total knee arthroplasty. J Arthroplasty 2011; 26:1273–1284.
[30] Bauwens K, Matthes G, Wich M, et al. Navigated total knee replacement. A meta-analysis. J Bone Joint Surg Am 2007; 89:261-269.
[31] Chi-Kin L, Hok-Yin L, Yiu-Chung W, Yuk-Leung W. Total knee replacement with iASSIST navigation system: iASSIST 電腦導航系統在全膝關節置換術的應. J Orthop Tra Rehab 2018; 24:29-33.
[32] Matthew C. Kinney KR. Comparison of the iAssist handheld guidance system to conventional instruments for mechanical axis restoration in total knee arthroplasty. J Arthroplasty 2018; 33:61-66.
[33] Canale ST, Beaty JH. Campbell's operative orthopaedics: expert consult premium edition-enhanced online features. Part III, Philadelphia, PA 2012; 404.
[34] Burnett RSJ, Barrack RL. Computer-assisted total knee arthroplasty is currently of no proven clinical benefit: a systematic review. Clinical Orthop Rel Res 2013; 471:264-276.

[35] Hetaimish BM, Khan MM, Simunovic N, Al-Harbi HH, Bhandari M, Zalzal PK. Meta-analysis of navigation vs conventional total knee arthroplasty. J Arthroplasty 2012; 27:1177-1182.
[36] Ensini A, Catani F, Leardini A, Romagnoli M, Giannini S. Alignments and clinical results in conventional and navigated total knee arthroplasty. Clinical Orthop Rel Res 2007; 457:156–162.
[37] Brin YS, Nikolaou VS, Joseph L, Zukor DJ, Antoniou J. Imageless computer assisted versus conventional total knee replacement. A Bayesian meta-analysis of 23 comparative studies. Int Orthop (SICOT) 2011; 35:331–339.
[38] Jung KA, Lee SC, Ahn NK, Song MB, Nam CH, Shon OJ. Delayed femoral fracture through a tracker pin site after navigated total knee arthroplasty. J Arthroplasty 2011; 26: 505-511.
[39] Hoke D, Jefari M, Orozco F, Ong A. Tibial shaft stress fractures resulting from placement of navigation tracker pins. J Arthroplasty 2011: 26:504-508.
[40] Fujimoto E, Sasashige Y, Nakata K, Yokota G, Omoto T, Ochi M. Technical considerations and accuracy improvement of accelerometer-based portable computer navigation for performing distal femoral resection in total knee arthroplasty. J Arthroplasty 2017; 32:53-60.
[41] Scuderi GR, Fallaha M, Masse V, et al. Total knee arthroplasty with a novel navigation system within the surgical field. Orthop Clin North Am 2014; 45:167-173.
[42] Desseaux A, Radiographic PG. Outcomes in the coronal plane with iASSIST™ versus optical navigation for total knee arthroplasty: A preliminary case-control study. Orthop Traumatol Surg Res 2016; 102:363-368.
[43] Abdel MP, Oussedik S, Parratte S, Lustig S, Haddad FS. Coronal alignment in total knee replacement: historical review, contemporary analysis, and future direction. J Bone Joint Surg 2014; 96:857–862.
[44] Eckhoff DG, Piatt BE, Gnadinger CA, Blaschke RC. Assessing rotational alignment in total knee arthroplasty. Clinical Orthop Rel Res 1995; 318:176-181.
[45] Wasiliewski RC, Galante JO, Leighty R, Natarajan RN, Rosenberg AG. Wear patterns on retrieval polyethylene inserts and their relationship to technical considerations during total knee arthroplasty. Clinical Orthop Rel Res 1994; 229:31-43.
[46] Rand JA, Coventry MB. Ten-year evaluation of geometric total knee arthroplasty. Clinical Orthop Rel Res 1988; 232:168-173.
[47] Bargren JH, Blaha JD, Freeman MA. Alignment in total knee arthroplasty. Correlated biomechanical and clinical observations. Clinical Orthop Rel Res 1983; 173:178-183.
[48] Hvid I, Nielsen S. Total condylar knee arthroplasty: prosthetic component positioning and radiolucent lines. Acta Orthop Scand 1984; 55: 160-165.
[49] Lotke PA, Ecker ML. Influence of positioning of prosthesis in total knee replacement. J Bone Joint Surg Am 1977; 59:77-79.
[50] Ritter MA, Faris PM, Keating KM, et al. Postoperative alignment of total knee replacement. Its effect on survival. Clinical Orthop Rel Res 1994; 299:153-156.
[51] Parratte S, Pagnano MW, Trousdale RT, et al. Effect of postoperative mechanical axis alignment on the fifteen-year survival of modern, cemented total knee replacements. J Bone Joint Surg Am 2010; 92:2143-2149.
[52] Vanniar SR, Wang LM, Yao QQ, Maddali T. iAssist versus conventional total knee arthroplasty in patients with varus and valgus deformities. Int J Res Orthop 2018; 4:350-356.
[53] Nam D, Cody EA, Nguyen JT, Figgie MP, Mayman DJ. Extramedullary guides versus portable, accelerometer-based navigation for tibial alignment in total knee arthroplasty: a randomized, controlled trial. J Arthroplasty 2014; 29:288–294.
[54] Matthew C. Kinney KR. Comparison of the iAssist handheld guidance system to conventional instruments for mechanical axis restoration in total knee arthroplasty. J Arthroplasty 2018; 33:61-66.
[55] Pickering S, Armstrong D. focus on alignment in total knee replacement. J Bone Joint Surg Am 2012; 94:1-3.
[56] Owens Jr RF, Swank ML. Low incidence of postoperative complications due to pin placement in computer-navigated total knee arthroplasty. J Arthroplasty 2010; 25, 1096-1098.
[57] Confalonieri N, Chemello C, Cerveri P, et al. Is computer assisted total knee replacement for beginners or experts? Prospective study among three groups of patients treated by surgeons with different levels of experience. J Orthop Traumatol 2012; 13:203–210.