Computer assisted Total Knee Arthroplasty, Comparison with the conventional technique

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Abstract

Objectives: This study was conducted to compare between computer assisted total knee arthroplasty and the conventional technique in operative time.

Mareials and methods:

30 patients with different degrees and forms of osteoarthritis of their knees and who are candidates for total knee arthroplasty were divided into 2 groups. Group 1 was named *PSI (Patient specific instrumentations)* [including 15 patients] using patient specific technique. Group 2 was named *Conv (conventional)* [including 15 patients] using conventional technique.

Operative time was measured for each patient of each group.

Results: PSI group would need much lesser time in the operative theater than Conv group by 24.3 minutes which had a statistical significance.

Conclusion: This study suggests that PSI technique has advantage over conventional instrumentation as it reduces operative time.

Keywords: Osteoarthritis, Patient specific instrumentation, Operative time.

Introduction

It is now agreed that the long-term total knee replacement results depend on lower limb realignment, proper implant positioning and sufficient ligament balancing. Improper alignment of the limb, Incorrect positioning or orientation of the implant and ineffective ligament balancing at the end of the surgical procedure can lead to accelerated implant wear and loosening as well as suboptimal functional performance.[(1)]

Greater than 3° varus or valgus mal-alignment in total knee replacement (TKR) can result in higher failure rates whilst correct alignment has been associated with improved clinical outcome. [(2)]

Malalignment can result in early postoperative complications, including loosening; instability and polyethylene wear. [3]

PSI is a new computer assisted technique for TKA that allows the performance of TKA virtually and the transfer of the virtual plan to physical templates that can be used by the surgeon as custom-made cutting blocks to completely perform the TKA procedure. This technique was first reported by *Hafez MA et al* (March 2006) using 45 experimental TKA procedure and proved to be less invasive, time saving and more accurate than conventional instruments. This patient specific technique (PST) is now used worldwide especially in Europe and North America with several reports in the literature. [4]

Computer-assisted orthopaedic surgery (CAOS) refers to an evolving technology of computerized systems that provide additional information during surgical procedures. Authors have proposed that the advantages of computer assisted orthopedic surgery include: an increase in accuracy, less invasive operations, better planning and simulation. [5]

CAOS tools will be used as the surgical trainers of the future by coupling simulations with real-time evaluation of surgical performance. [6]

Materials and Methods

30 patients with different degrees and forms of osteoarthritis of their knees and who are candidates for total knee arthroplasty were divided into 2 groups:
Group 1 was named *PSI* [including 15 patients] using patient specific technique.
Group 2 was named *Conv* [including 15 patients] using conventional technique.

Operative time was measured for each patient of each group.

Statistical analysis: All the grouped data were statistically evaluated using statistical package for social sciences (SPSS) program (windows version number 10) and the obtained data were analyzed by one-way ANOVA. Data were considered statistically significant with a P value < 0.05. [7][8]

Results

In the present study, 30 knees were reviewed in 30 patients including 21 females and 9 males with age ranges from 45-71 years. All 30 cases underwent total knee replacement as a treatment of their end stage painful disabling knee osteoarthritis, which is no longer responsive to conservative treatment.

Operative time was the primary end point in that study. It ranges from 85 minutes to 145 minutes in PSI group with mean 113 minutes and SD 19.06 minutes.

While in conv group it ranges from 90 minutes to 137.3 minutes with mean 137 minutes and SD 18.5 minutes.

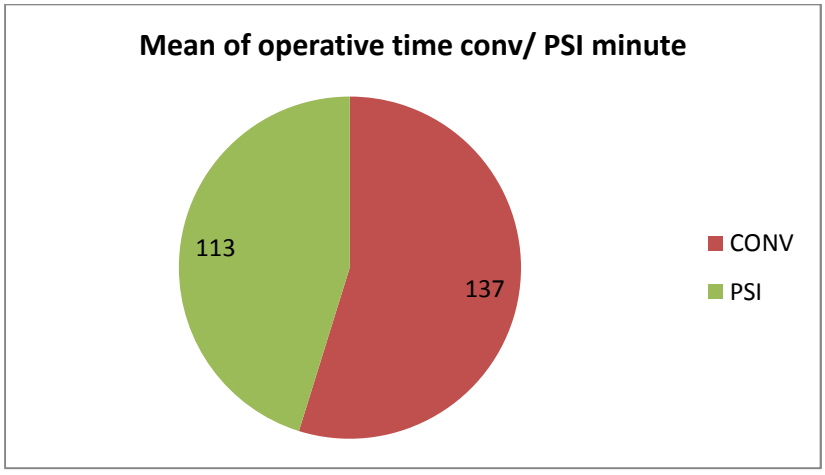

Fig.1: Pie chart showing mean of operation time of conv/PSI group

Table 1: showing the difference between PSI group & conv group in duration of operative time

Group (n/group=15patients)	Operative time/minutes mean±SD	SE/minutes
PSI group	**113 ± 19.06**	**4.9**
Conv group	**137.3 ± 18.5**	**4.77**
Group difference	**-24.33±0.56**	**6.86**
Statistically significant difference (p-value < 0.001)		

When comparing mean difference between two groups as shown in table 1 we could found that PSI group would take 24.3 minutes lesser in their operation than those in conv group. This value has a statistical significance.

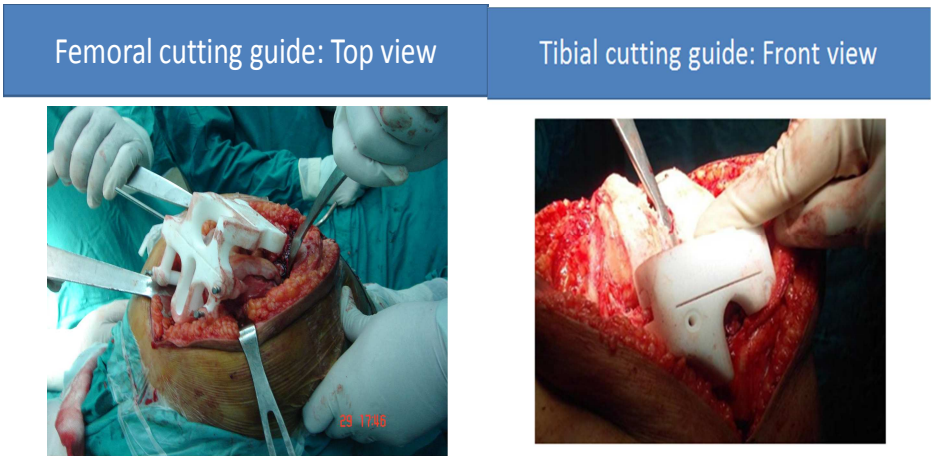

Fig.2: Femoral and tibial cutting guides in PSI technique (Intra-operative)

Fig.4: The difference in the number of instruments used in the PSI and conventional techniques

Discussion

The success of total knee replacement surgery depends on several factors, including proper patient selection, improved implant design, meticulous surgical technique, and strict perioperative care. [(9)]

Errors in positioning of the implant and improper alignment of the limb was believed to lead to accelerated implant wear and loosening as well as influencing functional performance. [(9)]

A number of studies have suggested that alignment errors of >3° - which are caused by errors in surgical techniques are associated with more rapid failure, less satisfactory functional results and high rates of revision after total knee Arthroplasty[(10)]

In 2004, Hafez and coworkers reported a new technique of using two-piece custom-made cutting guides instead of conventional instrumentation to perform TKA. Preoperative computer-assisted CT-based planning was used to design the templates (femoral and tibial cutting blocks) that were successfully used for 17 experimental cases (14 cadaveric and 3 plastic knee specimens) without resorting to conventional jigs. This work started in 2001 and the concept of this new technique was presented by these authors as a poster at a 2002 meeting of the International Society of Technology in Arthroplasty. A complete description of the technique, including the principles and experimental use for 45 TKAs, was presented by Hafez and associates in 2006, naming the technique patient-specific templating. [(11)]

In the present study, operative time was the primary end point. It was found that PSI group would need much lesser time in the operative theater than conv group by 24.3 minutes. Operative time ranged from 85 minutes to 145 minutes in PSI group

with mean 113 minutes and SD 19.06 minutes. While in Conv group it ranged from 90 minutes to 137.3 minutes with mean 137 minutes and SD 18.5 minutes.

Nunley RM et al (2011) observed that TKAs performed with patient-specific instrumentation had similar tourniquet times (61.0 versus 56.2 minutes) but patients were in the operating room 12.1 minutes less (137.2 versus 125.1 minutes) than those in the standard instrumentation group. They retrospectively reviewed 57 patients undergoing primary TKAs using patient-specific custom cutting blocks for osteoarthritis and compared them with 57 matched patients undergoing TKAs with traditional instrumentation during the same period (January 2009 to September 2010) in Saint Louis, USA. [(12)] Their results were coincided with the present study results, although the big difference in sample size. This is because PSI can reduce the amount of trays and instrumentation required. Also, Planning and possibly virtual surgery is performed on the computer before it is done on real patients.

Hafez MA et al (2006) also noticed that the operative time for the patient specific templating technique was reduced in comparison to the conventional technique. This was more pronounced when surgery was done without assistance. The mean time for bone cutting was 9 minutes with a surgical assistant and 11 minutes without an assistant. They performed 45 total knee arthroplasties on 16 cadaveric and 29 plastic knees, including a comparative trial against conventional instrumentations.[(11)]

It was noted in the present study that the number of instruments used during surgery in PSI group were fewer compared with the standard instrumentation group.

Noble (2012) noticed that the customized group also benefited from shorter operative time and the use of fewer instrument trays compared with the standard instrumentation group. In his study, 15 patients were operated on with a customized instrument set and 14 randomly selected patients were operated on with a standard instrumentation set for their primary total knee replacements. [(13)]

Although this study is small in scope as our study, it certainly demonstrates what is possible with a patient customized system.

In the present study, the preoperative planning was supervised by the surgeon, that's why the cutting blocks were fitting securely on the bony surfaces.

Whereas Howell et al (2008) who retrospectively reviewed 48 patients who underwent TKA utilizing patient specific technique (OtisKnee system), did note that 3% of the tibial guides and 3% of the femoral guides did not fit securely on the bony surfaces in their series. Retrospectively, it was determined that the technician creating the preoperative plan did not align the MRIs correctly, highlighting that human error can still occur with the use of patient specific techniques. [(14)]

However, despite these mixed results, the principles of patient-specific cutting blocks were sound, and several companies currently offer this technology. [(14)]

But, it was noted in the present study that the cutting blocks were not fitting properly in patients who did the preoperative CT scan of the knee long time before the

surgery, this might be due to the emergence of new osteophytes in the knee of the patient. Future studies should be considered to further evaluate this issue.

A preoperative CT scan of the knee was performed for patients undergoing TKA using PSI technique in the present study. The CT images were used for planning of surgery and manufacturing of the templates. CT scan images are imported to a computer with specific medical software and displayed in coronal, sagittal and transverse planes and segmented from the soft tissues. Component sizing is initially determined by measuring the antero-posterior (AP) dimension of the distal femur and the contour of the proximal tibia. This allows the selection of an exact or closely matched size of the femoral and tibial implants from the CAD files. Hafez MA et al (2006) also used a CT-based cutting block system.

While Spencer et al (2009) reported the results of 21 patients who underwent TKA using an MRI-based cutting block system. They noted a mean decrease in operative time of 14% compared with a cohort of patients with conventional knee replacements. [15]

Their results were also going hand in hand with the results of the current study although the different method of preoperative imaging. Future studies should be considered to further evaluate the difference between the use of CT scan versus MRI preoperatively for planning of the surgery and manufacturing of the templates.

Conclusion

The custom-made cutting guides are a revolutionary step in the development of TKA. This new concept exploits the capability of using computer-assisted preoperative planning software to provide patient-specific instruments that could replace conventional instrumentation systems.

Preoperative CT images are acquired and imported to a special software system that has three-dimensional data of the TKA implant to be used. Planning and possibly virtual surgery is performed on the computer before it is done on real patients.

This includes sizing, alignment, bone cutting, and verification of optimal implantation and positioning. Two virtual templates (femoral and tibial cutting guides) are designed and then transformed into physical guides using rapid prototyping technology.

The guides have built-in information of the pre-operative planning that can be transferred to the patient’s knee when the guides are positioned on the matching surfaces of the distal femur and proximal tibia.

Then, surgeons can use these guides to make all necessary cuts or to guide the position of the conventional cutting blocks.

These patient-specific guides should be used once because they are designed based on the surfacing matching of the patient's anatomy. TKA can then be done without using intramedullary or extra medullary guides.

The technique has several advantages over conventional instrumentation. It eliminates medullary guides, reduces operative time, and provides better accuracy. It is a simple technique that can be an alternative to navigation for TKA. However, further clinical studies are needed to confirm the results of limited clinical studies. Until this is done, the custom-made cutting guide technique should be used with caution and ideally should be confined to clinical trials.

To summarize, the benefits of this technique include the following:

1. Decrease the operative time and this might enables the surgeon to do bilateral simultaneous TKA.
2. Reduces the number of instruments used during surgery and this decreases the operative time and might reduce the risk of infection.
3. Potentially reduces the risk of fat embolism and bleeding as the femoral canal is not opened intra-operatively.

In conclusion, it was found that PSI group would need much lesser time in the operative theater than conv group by 24.3 minutes which had a statistical significance.

This technique is somehow new in the Middle East, future studies should be considered to further evaluate this technique especially long term results. In addition, it remains to be seen whether hospitals and surgeons can capitalize on the proposed increase in surgical and operating room efficiency. Future studies should be considered also to further evaluate the difference between the use of CT scan versus MRI preoperatively for planning of the surgery and manufacturing of the templates.

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التغيير الكامل لمفصل الركبه بواسطة الحاسب الألى مقارنة مع التقنية التقليدية

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هدف البحث :

الهدف الأساسى من هذا البحث هو عمل دراسة للمقارنه بين نتائج تغيير مفصل الركبة بمساعدة جهاز الحاسب الآلى وبين النتائج الخاصة بنفس الجراحة التى تجرى بالطريقة التقليدية.

المرضى الخاضعون للبحث:

- المرضى الذين يعانون من خشونه متقدمه بمفصل الركبه و على استعداد لاجراء عملية الأستبدال الكامل لمفصل الركبة.
- المرضى البالغون من العمر بين 45 – 79 عاما من الجنسين.

نتائج البحث:

تعد القوالب الالكترونية خطوة ثورية في تطوير عملية الأستبدال الكامل لمفصل الركبة. هذا مفهوم جديد يستغل القدرة على استخدام الحاسب الالى و برامج التخطيط قبل الجراحة لتوفير أدوات محددة يمكن أن تحل محل الأدوات التقليدية.

يتم التصوير المقطعي لمفصل الركبه للمريض قبل العملية و يتم وضع هذه الصور ببرنامج خاص يحتوى على بيانات ثلاثية الأبعاد لزرع الركبة الصناعية بالكامل. يتم إجراء العملية الجراحية ظاهريا على جهاز الحاسب الآلى قبل أن يتم ذلك على المريض. ويحتوى هذا البرنامج على بيانات لقياس التحجيم، والمحاذاة، وقطع العظام، والتحقق من الغرس الأمثل وتحديد المواقع. و يتم تصميم القوالب الافتراضية، أدلة قطع للفخذ والقصبة، ويتم تحويلها إلى الأدلة المادية باستخدام تكنولوجيا النماذج الأولية السريعة.

يمكن للجراحين استخدام هذه الأدلة لجعل جميع خطوات إعادة تسطيح المفصل اللازمة أو لتوجيه القطع التقليدية. ينبغي أن تستخدم هذه القوالب الالكترونية للمريض مرة واحدة لأنها مصممة استناداً إلى مطابقة التسطيح من تشريح الركبة للمريض ثم يمكن أن يتم استبدال الركبة بالكامل دون استخدام أدلة داخل النخاع أو أدلة خارج النخاع.

فلقد تبين ان عملية الأستبدال الكامل لمفصل الركبة بمساعدة الحاسب الالى عن طريق استخدام القوالب الالكترونيه تتميز بالزيادة في الدقة، تحسين التخطيط، والتوفير فى وقت اجراء الجراحه.