Interest Of Navigation Surgery In Total Knee Arthroplasty

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Abstract: The number of patients eligible for knee replacement has increased significantly in recent years and to the lengthening of life expectancy, patient expectations in terms of longevity of the prosthesis and improve surgical outcomes are strong. Conventional instruments have been for years (and still now) a great help to position the best prostheses, but studies show the pitfalls and shortcomings of these instruments; default axis in the frontal, sagittal or horizontal and failing to keep a ligament balance inflexion and extension. Surgical navigation can help control these parameters. There are navigation systems with preoperative imaging (CT), with other intraoperative imaging (fluoronavigation) and systems without preoperative or intraoperative imaging that are currently the most commonly used systems, these are passive systems, corresponding to akinematic model and palpation where the surgeon is master of his actions and decisions. The results of the series found in the literature are quite remarkable because it demonstrates an accuracy rate of implantation (HKA180 plus or minus 3 °) between 92% and 100% with good management the ligament balance, with the navigation system film. Unfortunately the high cost of these systems represents a brake on growth without government assistance or decreases their purchase price.

Keywords: Knee prosthesis , navigation , computer

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INTRODUCTION

The number of eligible knee arthroplasty patients has increased significantly in recent years. Now these replacements are no longer confined seniors and the profile of the affected population has changed considerably. Since the 80s, surgeons and engineers work together to develop computer software guide. Thus was born the computer aided surgery also called surgical navigation. The implementation of total prosthesis computer-assisted knee is a recent technique since the first settlement on the living dated 21 January 1997 (1). This is a technical innovation that cannot be ignored because if some young or less young surgeons are very enthusiastic, others show certain skepticism and try to demonstrate that the conventional technique, as regards correction of axial strain, gives almost as well as computer-assisted surgery (2). The objective of our study is to present the procedure of conduct of the surgical navigation, its advantages compared to conventional techniques in total knee arthroplasty.

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MATERIALS AND METHODS

The material is composed of a navigation station to the space real-time tracking of markers, as well as an ancillary adapted to this navigation. Navigation station has a PC computer, infrared locator Polaris (Northern Digital Inc) and a dual footswitch. The course of the operating protocol is defined in the software and provides the surgeon with the foot control and a dedicated GUI. This navigation station further comprises ancillary items that are markers and their fixings. A marker, also called "rigid body" is constituted by an assembly of infrared diodes connected rigidly.Currently, these markers were originally active markers (connected by a wire to the navigation station and emitting a light signal) are passive markers that reflect light. The bone attachment markers are effected by means of special two cortical screws. The ancillary features cutting guides equipped with markers that are firmly attached to the bone by 3 or 4 threaded spindles. The cutting guide chamfers can also do the anterior and posterior sections.

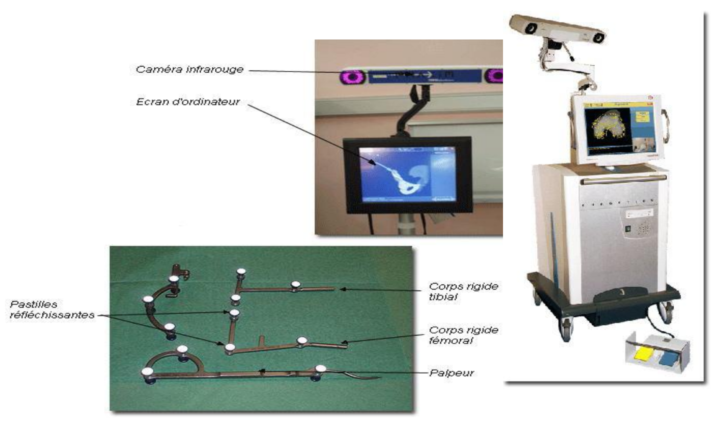


Fig1: Navigation equipment

The preoperative planning is exactly the same as setting up prosthesis by the conventional technique: plain radiographs or better pangonométrie responsible for assessing the axis and the shape of the femur and tibia. Surgery is performed under tourniquet, which minimizes the use of foreign blood or patient's own blood. By means of infrared technology, the trackers placed on the femur and the tibia bidirectionally communicate with the navigation device. The surgical approaches are median and lateral are possible.

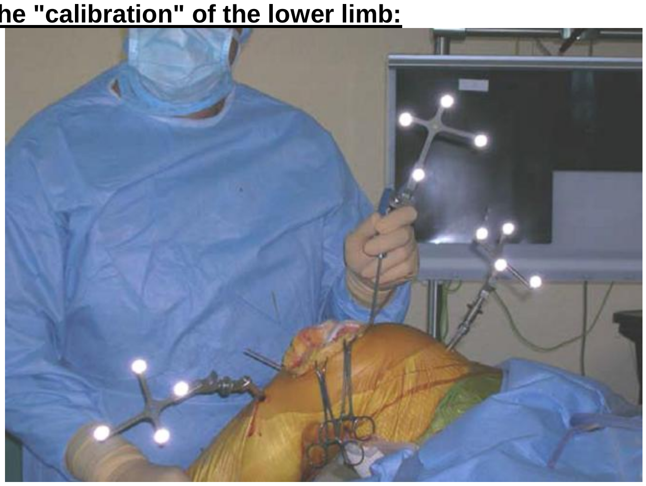
1- Acquisition of the one-axis mechanical

Placing markers:
To reduce the length of the incision, the femoral and tibial markers are inserted percutaneously and positioned so they can be seen throughout the procedure without it being necessary to move the locator.

Fig2: The position of the front knee inserting markers

Fig3: Palpation over the femoral trochlea.

The "calibration" of the lower limb:



The calibration member is to seek the center of the femoral head (H), the center of the knee (K) and the center of the pin (A) by appropriate movements of the hip, knee and ankle. Locating the center of the femoral head is to make a circular movement of the lower limbs, small diameter, knee extension or flexion, slowly and gradually, allowing the locator to track infrared diodes perfectly rigid body and femoral locate the center of the femoral head.

Fig4: Locating the center of the femoral head

Locating the center of the ankle is more complex than the hip since has only one degree of freedom, which allows only search an axis of rotation. For this it is necessary to place a rigid body at the proximal end of the tibia and one on the neck of the slope by means of a metal plate and an elastic strap, which prevents an incision in the neck of the foot. Flexion -extension and palpation of the malleolus and the middle of the tibiotalar allow, thanks to the finder and infrared diodes, locate the center of the ankle (3). Locating the center of the knee is also relatively complex, since it is an instantaneous center of rotation and it moves during the rotation. The flexion- extension give initially flexion extension axis; movement of axial rotation of the tibia when the knee is flexed to 90 °, give another axis; the intersection of these two lines gives the center of rotation of the knee. To calculate this area, the localizer will follow the movement of rigid bodies initially introduced at the lower end of the femur and the proximal tibia (3).

Steps palpation:
Palpation of the tibial plateau (healthy and worn) will determine the height of cut. Using the probe which is fixed rigid body moving, it feels healthy tea in the middle, and not before, to incorporate a portion of the posterior tibial slope. It also feels the mid tibial spines and the top of the femoral notch to improve the robustness of the research center of the knee.

Fig5: Palpation of the tibial plateau

Palpation of the femur (posterior face of the medial condyle, the lateral posterior condyle, the medial condyle of the more distal and lateral cortex and the anterior trailer) will determine the size of the prosthesis ensure the center of the femur joint and give the valgus or varus femoral. Palpation of the epicondyles gives an idea of the distal femoral epiphyseal torsion of the femur.

Fig6: Palpation of the femur

Palpation of the ankle can integrate its center, which consolidates acquisitions obtained at the time of the kinematic calibration. Must palpate the tip of the medial malleolus, the tip of the lateral malleolus and the environment tibio-talar.

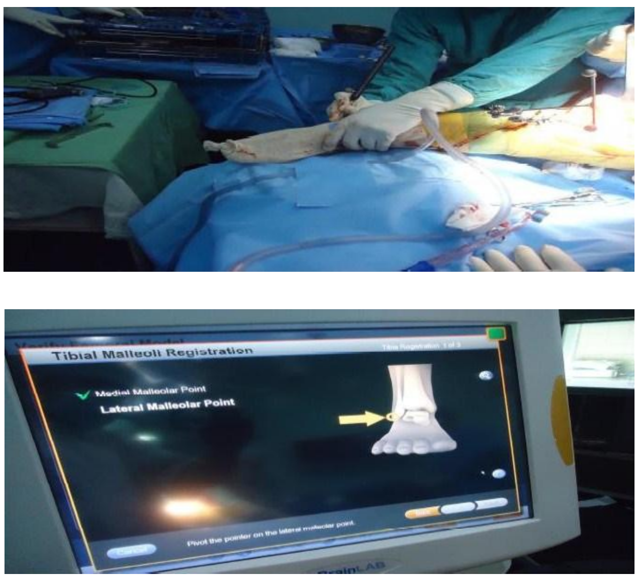


Fig7: Palpation of the ankle

At this stage of the procedure, the points H, K and A have been found and their known coordinates in the reference system of rigid bodies of the tibia and femur. The mechanical axis of the lower limb is determined and can be compared to preoperative pangonométry. The size of the prosthesis is also known and displayed on the computer screen (3).

2-Navigation:

Varus or valgus With Stress printed by the operator, ballast l can have a stress geometry in which to test the reducibility and know in advance whether it will have to move towards a release or not soft tissue devices. In addition, the system also provides a dynamic geometry which assesses the varus or valgus flexion to 30 (position of walking) and 90 which gives an idea of the overall femoral rotation (3) notion completely ignored so far , especially overlooked when we put the systematic external rotation in the femoral implant in conventional techniques. The tibial cutting guide is mounted on a support which adjusts the varus - valgus, cutting height and posterior tibial slope. We currently prefer to place the cutting guide "on the fly", without any support, which allows you to make skin incisions shorter. It is placed in front of the tibia with its rigid body and is fixed to the bone by 4 threaded pins as soon as the correct settings are displayed on the screen, we know for 0° valgus-varus, a posterior tibial slope between 0 and 2 and a height of 8 or cutting 10 mm corresponding to the thickness of the tibial plateau prosthesis. Once the comb sets, cutting is performed with an oscillating saw.

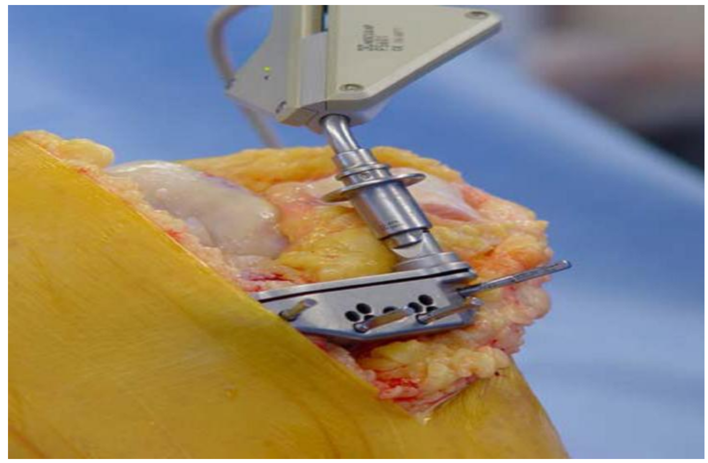


Fig8: Inserting the tibial cutting guide

The femoral cut guide mounted to the rigid body is then placed against the front face of the distal end of the femur knee flexed to 90 °, after the projection of the resected femoral trochlea. You can use the appropriate support or implement this cutting guide "on the fly" which allows a less extensive way first. Varus - valgus is then adjusted (0°), the posterior slope (between 0 and 2 flexions to avoid notching the anterior cortex), and the height of the resection (resection of the minimum side of the convexity to reduce the problems ligament balance). At this stage of the procedure, the alignment " bone " of the lower limb was performed by the computer and the implantation of the prosthesis continues with the classic ancillary particular to achieve the previous sections , posterior and chamfer .

Implementation of the prosthesis:

The implementation of the test prosthesis can check through the computer, the axis of the lower limb extension in the position of walking and bending to 90 and ligament balance by measures stress both valgus and varus that have a measure of the degree yawn medial or lateral. The axis of the lower limb may also be checked upon final implantation of the prosthesis which can sometimes be detected excessive lateral or medial cement capable of changing the axis of one or two (1 mm cement=1) (3).

The rotation of the femoral implant:

We never say, systematic, external rotation of the femoral implant at least in the Genoa - forum. We rotation solely on the valgus or varus femoral. If a gene varus, valgus femur is 3 or more, we think it makes sense to put external rotation because it will resect more distal medial condyle and therefore more posterior candle if we wants ligament balance is balanced in flexion (3). This rotation does not need to be navigated as the ancillary device can easily provide this rotation. If the femur is in varus , and in so far as the Genoa varum hyper is reducible , it also makes sense to set the internal rotation because less medial distal condyle therefore less posterior medial condyle (3) on réséquera . In case of genu valgum, external rotation is common but not required, because the femoral valgus is almost constant but the posterior femoral hypoplasia of the lateral condyle is far from being the rule. We generally 1 to 1 rotation of the femoral valgus not exceeding 5-6 rotation for not having a too large size of the anterolateral cortex of the femur (3).

Ligament balance:

One can proceed in two different ways: on the basis of tests the reducibility of deformation (stress valgus and varus by the extension) or by following the management software ligament balance. We prefer to use the first method that allows the surgeon to think and remain master of his choice. We proceed as follows : when the axis of the lower limb appear on the computer screen , before any removal of osteophytes, we apply a manual force varus and valgus knee being 5 or 10 flexions to assess the reducibility of the deformity and yawning in the convexity. If the deformity is reducible or reducible hyper, we are certain that the balance Extension is balanced and it will not be necessary to release soft tissue in the concave. It is the same if the reducibility gives a hypo correction 3 to 5 °. If hypo correction is larger, it will provide a gradual release of the soft parts of the concavity with the test implants, after removal of osteophytes. However, be aware that a perfectly balanced scale does not mean, necessarily, that there is a symmetrical yawn between the medial and lateral side, because we know that in a normal knee the lateral compartment is more lax than the medial compartment. So we welcome in the genu varum, a senior yawn March-April at the lateral compartment of the knee. As regards the management of spaces between the extension and flexion, we never imbalance because on one hand we use in most cases a prosthesis with preservation of the posterior cruciate ligament and it is a good goalkeeper spaces and secondly we resect a bone thickness equal to the thickness of the implants. Thus, the balance was good before the TKA has no reason to change after the introduction of the prosthesis. Finally, the medial-lateral balance in flexion can be controlled without any distraction, because we believe that this is an artificial process that does not guarantee a good balance as tensing of each side is subjective and poorly reproducible(3). To verify this balance, it is sufficient once the cutting guide chamfers established at the distal femur, thigh lift through the fulcrum, pull manually on the axis of the leg knee flexed to 90 ° and check the parallelism of the cutting guide with the cup the tibial plateau. In the Genoa varum, parallelism is perfect in most cases and it is not necessary to release the soft parts. Otherwise, and especially in the Genoa valgum case, you must make a gradual release of the medial or lateral capsular ligament level (3).

RESULTS

This is a reliable technique that in over 95 % of cases to obtain a mechanical axis of between 177 and 183 and a better establishment of the codylar and tibial parts around 90 both in the frontal plane than in the sagittal plane. For over 10 years, software has been regularly improved to a remarkable reliability throughout all hands. It is particularly well suited for minimally invasive surgery, since it is not useful to open widely the knee to identify reliable and reproducible the center of the knee and the anatomical points of Interest that will guide the bone cuts and the choice of the size of the prosthesis (3).

DATA PER / POST OPERATIVE:

1-Operating Time

The duration of the operation is increased by an estimated 14 minutes which is acceptable in routine practice average. Some authors emphasize, however, that time is reduced with experience.

2-Blood Loss

Conflicting results have been obtained. In some studies, blood drainage and haemoglobin loss were lower in the group of patients operated on by the computer-assisted surgery. These studies concluded that the risk of transfusion was therefore reduced. Other studies on the contrary did not reveal any significant difference in blood loss between the 2 types of surgery (4).

3-Complications

Embolism: The occurrence of embolic events cruoriques or fatwas analyzed in a meta-analysis (5). No differences between groups were reported. infectious complications: The infection is a rare but severe complication because that may require further surgery. The occurrence of severe or superficial infection was analyzed in a meta-analysis (5): no significant difference was found between the groups in rates of infection. Complications specific to navigation: Complications isolated specific navigation have been reported:
-three cases of fractures and drill spindle 1 forgetting hip screw (6,7);

- 1 Supra condylar fracture cases after a full one month after intervention (8).
- A case of abandonment of navigation for conventional surgery during surgery in an obese patient (center determination impossibly hip) (9) and 6 cases of abandonment due to the mobility of rigid bodies in a bone of poor quality (10).
- The members of the working group stressed the exceptional occurrence of femoral fracture and the potential risk of vascular and nerve injury associated with the use of pins for navigation. However, the material has evolved; the pins are now standard and less aggressive.

PROGNOSIS: SURVIVAL / REPEAT

Among the studies, only one reported a 10-year follow-up (11) 20 patients operated among the 26 patients included in the baseline (3 dead, 1 lost sight of one operation at 5 years because of polyethylene wear and 1 awaiting further surgery because of the loosening of the femoral component). Of these 20 patients remaining, the authors observed 90% survival rate and 85% satisfaction rate (15% of patients not taking advantage of their prosthesis for another reason: Parkinson's disease, spinal disability, non-operated hip osteoarthritis).

LEARNING CURVE:

A study specifically analyzing the learning curve has been identified (12). This study compared the installation in terms of precision PTG implantation, clinical outcomes, response duration and complications in two groups, a control group consisting of centers with experienced surgeons (150 PTG) and a study group consisting of centers with novice surgeons (218 PTG) (12). At 3 months, no significant difference between the 2 groups was demonstrated for the parameters evaluated except for the duration of intervention, however, this increase in the duration of intervention in centers with surgeons beginners disappeared after 30 implantations.

DISCUSSION

Whatever systems are used, we can say today that the computer browser to locate the knee prostheses with greater precision than conventional techniques, at least as regards the bone alignment. Although a recent study (13) shows that with a good Planning and with good ancillary conventional can perfectly align a prosthesis in 87% of cases, this is far from being the rule and there are many studies that show the limits of ancillary manuals whether or extramedullary, intramedullary (14). Moreover, aiming at femoral intramedullary was developed because of the lack of precision of the extramedullary referred. However, it is not a trivial technical and if we can do without why deprive especially at the hour of minimally invasive surgery (15,16). On the other hand this has limits referred intramedullary especially when there is a melunion of the femur or tibia (17,18) or when one has to do with a femur or tibia curve which is relatively common in certain ethnic groups (19). As regards the adjustment of the rotation of the femoral implant, the advantage of the navigation does not appear even if demonstrated Stöckl et al. (20) believe that this setting improves navigation. Indeed, the setting of this rotation is under the control of the epicondyles of palpation which is powered by the surgeon himself, which is a source of error regardless surgeon experience (21,22). It is the same for all stages of palpation (23) unless palpation anatomically not ready for any error, which is the case of clearly visible and not covered by bone or joint ligament insertions surfaces. This is why we prefer to adjust the rotation depending on the mechanical axis of the femur and condylar posterior plane bi-line without using the bi- or Whitside epicondylar axis. It is the same for the rotation of the tibial implant (24) which is in response to palpation the surgeon that provides no superiority over conventional surgery. Regarding finally ligament balancing, most navigation systems offer software that allows, through spacers or destructor automatically adjust ligament balance according to the mechanical axis. However, no study has been able to verify that the equilibrium given by the navigation was higher than that could be obtained with conventional instrumentation. If this assessment seems relatively easy using extension radiographs to assess stress in the medio-lateral yawn, this seems much more difficult flexion. This is why, again, we use the computer as an indispensable tool for ligament balance (25) without incurring the software's indications. Which system to choose? The current trend is strongly in favor of pre-or intraoperative imaging without systems as suggested by the international literature. Their performances are similar and only the graphical interfaces change. Beware screens that contain a number of significant data born, not always necessary, which will distract the surgeon. Reading and interpretation of these data are a waste of time that inevitably sounds for the duration of the intervention. Currently, the time spent in data acquisition should not exceed 7-8 minutes and the the navigation should not take longer than using a conventional ancillary. If it has now proven, that allows a better navigation of implant prostheses in terms of the alignment radiation, it has not absolutely demonstrated that the lifetime has been increased and the rate of recovery was reduced. It certainly takes more distance, but we also know that the life also depends on the design of the prosthesis and quality polyethylene. Gold dentures regularly change, and some technical improvements are quite noticeable making some revisions questionable long-term prostheses that are no longer marketed. Given the results of some historical studies, one might assume that a good prosthesis, with a very good and perfectly located polyethylene will last better life ... But everything remains to be demonstrated. As for the cost of navigation systems, it may be an obstacle to their development. It is likely that with their broadcasts, the cost will decrease as with all computer systems that have emerged over 20 years, but the global orthopedics market is sufficient to put these systems to price a conventional ancillary? Only the future will tell.

CONCLUSION

The introduction of total knee prostheses with computer assistance today allows better positioning of the implants than conventional surgery, at least with regard to the alignment radiation. However a well- focused aid is not necessarily good setting and other parameters must be taken into account, as the ligament balance and patellar tracking. Software manager ligament balancing have not yet been validated by appropriate tools and education. There remains the navigation is likely to guide the surgeon in integrating the mechanical axis of the lower limb in its management of ligament balance. Anyway, it remains to demonstrate that aid will be well focused life than a prosthesis less focused knowing that it will get rid of the design of the prosthesis and quality polyethylene are other factors that influence longevity.

REFERENCES

[1]. Saragaglia D, Picard F. Computer-assisted implantation of total knee endoprosthesis with no pre-operative imaging : the kinematic model. In : Stiehl JB, Konermann WH, Haaker RG, éds. Navigation and robotics in total joint and spine surgery. Berlin, Heidelberg : Springer-Verlag ; 2004. p. 226–33.

[2]. Lerat JL, Besse JL, Desmé D, Kadi S, Chouteau J, Rollier JC, et al. Précision des coupes osseuses dans l'arthroplastie totale du genou à l'aide d'un ancillaire conventionnel: trois cent poses consécutives de prothèses Innex[R]. Rev Chir Orthop 2006 ; 92 : 248–56.

[3]. DOMINIQUE SARAGAGLIA. Computer assisted total knee arthroplasty: Grenoble 12 years experience.e-memmoires de l'académie nationale de chirurgie, 2009, 8(1):53-58

[4]. Chin PL, Yang KY, Yeo SJ, Lo NN. Randomized control trial comparing radiographic total knee arthroplasty implant placement using computer navigation versus conventional technique. J Arthroplasty 2005 ; 20 : 618–26.

[5]. BAUWENS.K, MATTHES.G, WICH.M, F.HANSON.

Navigated total knee replacement.a metanalysis.j.bone joint surg am 2007, 89(2):261-9.

[6]. VICTOR.J, HOSTE.D. Image-based-computer-assisted-total knee arthroplasty leads to lower variability in coronal alignement.clin orthop relat res 2004 ; (428):131-9

[7]. JENNY.JY, CLEMENS.U, KONNERMAN W. Consistency of implantation of total knee arthroplasty with non image based navigation system: a case control study of 235 cases compared with 235 conventionally implanted protheses.j arthroplasty 2005; 20(7):832-9

[8]. MULLAGY.A, KANNA .R, KOHL. A.comparison of limb and componment alignement using computer assisted navigation versus image intensifer-guided conventional total knee arthroplasty: a prospective, randomized single –surgeon study of 467 knees.j arthroplasty 2007; 22(7):953-9

[9]. cather.re, rush .pf, smith.wl.experience with computer assited navigation for total knee arthroplasty in community setting.j.arhtroplasty 2008; 23(5):707-13

[10]. TINGART.M, LURING.C, PERLIK.L. Computer assited total knee arthroplasty versus the conventional technique: how precise is navigation in clinical routine? Knee surg sports traumatol arthrosc 2008, 16(1):44-50

[11]. SARAGAGLIA.D, PICARD.F. 10 years follow up of 26 computer assisted total Knee arthroplastties.orthopedics 2007; 30:s121-s123

[12]. JENNY.JY, GIUREA.A.A. Learning curve i navigated total knee replacement .a multicentre study comparing experienced and beginner centres knee2008; 15(2):80-4

[13]. Lerat JL, Besse JL, Desmé D, Kadi S, Chouteau J, Rollier JC, et al. Précision des coupes osseuses dans l'arthroplastie totale du genou à l'aide d'un ancillaire conventionnel : trois cent poses consécutives de prothèses Innex^{R}. Rev Chir Orthop 2006 ; 92 : 248–56.

[14]. Mahaluxmivala J, Bankes MJ, Nicolai P, Adlam CH, Allen PW. The effect of surgeon experience on component positionning in 673 press fit condylar posterior cruciate-sacrificing total knee arthroplasties. J Arthroplasty 2001 ; 16 : 635–40.

[15]. Kalairajah Y, Simpson D, Cossey AJ, Verrall GM, Spriggins AJ. Blood loss after total knee replacement. effect of computer-assisted surgery. J Bone Joint Surg (Br) 2005 ; 87-B : 1480–2.

[16]. Kalairajah Y, Cossey AJ, Verrall GM, Ludbrook G, Spriggins. Are systemic emboli reduced in computer-assisted knee surgery ? A prospective, randomized, clinical trial. J Bone Joint Surg (Br) 2006 ; 88-B : 198–202.

[17]. Fehring TK, Mason JB, Moskal J, Pollock DC, Mann J, Williams VJ. When computer-assisted knee replacement is the best alternative. Clin Orthop Relat Res 2006 ; 452 : 132–6.

[18]. Klein GR, Austin MS, Smith EB, Hozack WJ. Total knee arthroplasty using computer-assisted navigation in patients with deformities of the femur and tibia. J Arthroplasty 2006 ; 21 : 284–88.

[19]. Ko PS, Tio MK, Ban CM, Mak YK, Ip FK, Lam JJ. Radiologic analysis of the tibial intramedullary canal in chinese varus knees : implications in total knee arthroplasty. J Arthroplasty 2001 ; 16 : 212–5.

[20]. Stöckl B, Nogler M, Rosiek R, Fischer M, Krismer M, Kessler O. Navigation improves accuracy of rotational alignment in total knee arthroplasty. Clin Orthop Relat Res 2004 ; 426 : 180–6.

[21]. Jenny JY, Boéri C. Low reproducibility of the intra-operative measurement of the transepicondylar axis during total knee replacement. Acta Orthop Scand 2004 ; 75 : 74–7.

[22]. Siston RA, Patel JJ, Goodman SB, Delp SL, Giori NJ. The variability of femoral rotational alignment in total knee arthroplasty. J Bone Joint Surg (Am) 2005 ; 87-A : 2276–80.

[23]. Oberst M, Bertsch C, Lahm A, Wuerstlin S, Holz U. Regression and correlation analysis of preoperative versus intraoperative assessment of axes during navigated total knee arthroplasty. Comput Aided Surg 2006 ; 11 : 87–91.

[24]. Siston RA, Goodman SB, Patel JJ, Delp SL, Giori NJ. The high variability of tibial rotational alignment in total knee arthroplasty. Clin Orthop Relat Res 2006 ; 452 : 65–9.

[25]. Saragaglia D, Chaussard C, Rubens-Duval B. Navigation as a predictor of soft tissu release durind 90 cases of computer-assisted total knee arthroplasty. Orthopedics 2006 ; suppl to vol 29(10) : S137–38.