Interet de la navigation pour les PTG

Congrès GECO 2009 Les Arcs, 18 – 22 Janvier 2008

Philippe MERLOZ
University Department of Orthopaedic Surgery, CHU A. Michallon ; BP 217
38043 Grenoble Cedex France
Computer Assisted Knee Arthroplasty

Improve the quality of Total Knee Arthroplasty results

- Pain relief
- Range of Motion
- Stability
- Durability
- Alignment
Computer Assisted Knee Arthroplasty

- Improvements in ligament releasing
- Assessment of ligamentous stability
- Maximum range of motion and stability
- Navigation equipment
Computer Assisted Knee Arthroplasty

- **Functional result:**
  - preoperative management
  - surgeon’s skills
  - knee kinematics properties
  - bone quality
  - soft tissue damages
  - implant design
  - post-operative follow-up.

- **Longevity of the knee implant:**
  - material properties (polyethylene, cement)
  - implants positioning
Computer Assisted Knee Arthroplasty

- Soft tissue balancing
- Bone cuts alignment.

- CLINICAL CHALLENGE
- TECHNICAL CHALLENGE
Computer Assisted Knee Arthroplasty
Clinical Challenge

SOFT TISSUE BALANCING

• Knee laxities
• Range of motion
• Medial and lateral joint gap
• Patellar motion
• Flexion gap
• Extension gap
Computer Assisted Knee Arthroplasty
Clinical Challenge

- precise preoperative plan
- immediate and accurate intra-operative feedback information:
  - resection
  - orientation
  - alignment
  - range of motion
  - tension
Three main technologies are, at the present time, used for Computer Aided Knee Surgery:

- Pre-operative (passive) model *image based* (*CT based*) navigation systems.
- Intra-operative (passive) model *image free* (*non CT, non X rays*) navigation systems.
- Intra-operative (passive) model *image based* (*X rays, non CT*) navigation systems (*virtual fluoroscopy*).
Pre-operative (passive) model *image based* (CT based) navigation systems.

Surface-based registration

Pre-operative (passive) model *image based* (CT based) navigation systems.

- First available device
- The gold standard of CAOS systems
- The most important step is registration
- Registration requires sophisticated computer-based techniques
Intra-operative (passive) model *image free* (non CT, non X rays) navigation systems.

Point-based solution

Intra-operative (passive) model *image free* (*non CT, non X rays*) navigation systems.

A similar technology added the “bone morphing™” technique. Registration is performed between intraoperative data and a deformable statistical model.

Intra-operative (passive) model *image based* (X rays, non CT) navigation systems (*virtual fluoroscopy*).

Intra-operative (passive) model *image based* (*X* rays, *non CT*) navigation systems (*virtual fluoroscopy*).

- CT less navigation system
- No registration procedure
- Navigation on calibrated fluoroscopic images
- Calibration target is needed
Computer Assisted Knee Arthroplasty Results

- 1° CAOS systems
- 2° CAOS vs Conventional techniques
- 3° Computer-assisted soft tissue balancing
- 4° Unicompartmental knee replacement (UKR)
- 5° CAOS and Minimal Invasive Surgery (MIS)
- 6° Computer-assisted revision total knee arthroplasty

Computer Assisted Knee Arthroplasty

Results

• 1° CAOS systems
• CAOS vs Conventional techniques
• Computer-assisted soft tissue balancing
• Unicompartmental knee replacement (UKR)
• CAOS and Minimal Invasive Surgery (MIS)
• Computer-assisted revision total knee arthroplasty
CAOS Systems

CT based vs imageless navigation systems

• Both systems (CT based vs Imageless) are safe accurate and reliable
• Post-operative clinical and functional results are similar for both series
• No navigation-related complications
• Imageless and Fluo add ligament balancing capabilities
• Fluo add intra-operative assessment of implant position

Computer Assisted Knee Arthroplasty

Results

- CAOS systems
- 2°CAOS vs Conventional techniques
- Computer-assisted soft tissue balancing
- Unicompartmental knee replacement (UKR)
- CAOS and Minimal Invasive Surgery (MIS)
- Computer-assisted revision total knee arthroplasty
CAOS vs Conventional techniques
Alignment in the frontal plane

- HKA angle with CAOS:
  - 178° - 182°

- HKA angle with conventional:
  - 172° – 188°

CAOS vs Conventional techniques

Alignment in the frontal plane

Virtual Fluoroscopy

Victor & Hoste. CORR 2004 lower variability in coronal alignment.
CAOS vs Conventional techniques

Femoral and Tibial component

**Femoral component**
- CAOS better information on:
  - 1° varus/valgus orientation
  - 2° flexion/extension orientation

**Tibial component**
- CAOS better information on:
  - 1° varus/valgus orientation
  - 2° tibial slope orientation


CAOS vs Conventional techniques

Soft tissue balancing

- Most of the systems are equipped with soft and hardware to initiate a good soft tissue balancing
- The use of Trans Epicondylar Axis may improve the orientation of the femoral component and it would be able to give better informations for the equality between flexion and extension gap.

CAOS vs Conventional techniques
Informations displayed to the surgeon

- Plan of bone cuts on the femur and the tibia
- Parameters are displayed to the surgeon (HKA, varus, valgus ...) in 3D and in real time (flexion 0° – 120°)

Ilsar I, Joskowicz L et al. Navigated Total Knee Replacement – A comprehensive clinical state of the art study
In Frank Langlotz, Brian L. Davies, Randy E. Ellis eds. *Computer Assisted Orthopaedic Surgery*, Berlin, Pro-Business, 2006, 229-231
CAOS vs Conventional techniques

Operative time and blood loss

- **Operative time**: CAOS = increase operative time (20 mn)
  
  Set up
  Reference frame attachment
  Data acquisitions
  learning curve

- **Blood loss**: CAOS = no difference with

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CAOS vs Conventional techniques

Early complication rate and post-operative functional results

- Early post-operative complications rate is similar in both series.

- Post-operative clinical and functional (pain, walk and range of motion) results are similar for both series at twelve months.

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CAOS vs Conventional techniques

Long term follow-up and experienced CAOS surgical team

• No long term follow-up [> 5 years] (PE wear, longevity)
• No significant differences concerning the level of accuracy between experienced CAOS surgical team and non experienced CAOS surgical team
• Average learning curve: 20 surgical procedures

Computer Assisted Knee Arthroplasty

Results

• CAOS systems
• CAOS vs Conventional techniques
• 3° Computer-assisted soft tissue balancing
• Unicompartmental knee replacement (UKR)
• CAOS and Minimal Invasive Surgery (MIS)
• Computer-assisted revision total knee arthroplasty
Computer-assisted soft tissue balancing

- External rotation
- Soft tissue release

The ligamentous force balance is still qualitatively assessed by the surgeon through manual trial movements of the limb.
An objective and quantitative measurement of the forces acting within the knee would help the surgeon to improve the accuracy of the ligament balancing procedure.

Some force-sensing devices for TKA have been recently developed to provide precise, real-time, quantitative measurements, while permitting the patella to be kept at its anatomical place and ensuring a small bone resection. At the present time, these devices are still experimental and not available for a clinical practice.

Computer Assisted Knee Arthroplasty

Results

- CAOS systems
- CAOS vs Conventional techniques
- Computer-assisted soft tissue balancing
- 4° Unicompartmental knee replacement (UKR)
- CAOS and Minimal Invasive Surgery (MIS)
- Computer-assisted revision total knee arthroplasty
Unicompartmental knee replacement (UKR)

- Navigation systems for UKR improve the implant position of each component.
- Navigation systems increase indisputably the level of accuracy concerning AP and lateral alignment.
- At the present time, there is no long term (> 3-4 years) follow up results.

Unicompartmental knee replacement (UKR)

Minimal Invasive Surgery (MIS) + CAOS for UKR

- MIS + CAOS decrease pain, hospital stay, rehabilitation time (walk, stairs) and scar size.

- MIS + CAOS-UKR vs conventional technique: post-operative clinical and functional results (pain, walk, stairs, range of motion) are similar for both series at twelve months.
Computer Assisted Knee Arthroplasty

Results

• CAOS systems
• CAOS vs Conventional techniques
• Computer-assisted soft tissue balancing
• Unicompartmental knee replacement (UKR)
• 5°CAOS and Minimal Invasive Surgery (MIS)
• Computer-assisted revision total knee arthroplasty
CAOS and Minimal Invasive Surgery (MIS)

• Conventional TKA technique versus
• MIS + CAOS TKA versus
• MIS-TKA technique does not show significant difference between the results concerning the values of alignment in AP (HKA angle) and lateral plane (tibial slope).

• MIS + CAOS TKA versus conventional tech. : results are similar for both series at 12 months

CAOS and Minimal Invasive Surgery (MIS)

**YES**
- Decrease Blood Loss
- Decrease Pain
- Decrease Hospital Stay
- Decrease Rehabilitation Time
- Decrease Scar Size
- RX : No Significant Differences

**NO**
- Implant malposition
- Soft tissue damage (retractor)
- Implant specific design
- Specific instrumentation
- Prolonged Learning curve
- Extended operative time
- No randomized prospective study
- Excessive Media Coverage
- Soft tissue balancing ?

Computer Assisted Knee Arthroplasty

Results

• CAOS systems
• CAOS vs Conventional techniques
• Computer-assisted soft tissue balancing
• Unicompartmental knee replacement (UKR)
• CAOS and Minimal Invasive Surgery (MIS)
• 6° Computer-assisted revision total knee arthroplasty
Computer-assisted revision total knee arthroplasty

- Clinical challenge: adequate joint line and joint stability; loss of bone stock.
- Technical challenge: relevant bony landmarks
- Significant improvement of prosthesis alignment.

Computer Assisted Knee Arthroplasty
Conclusions and future challenges
Computer Assisted Knee Arthroplasty
Conclusions and future challenges

Alignment, CAS-TKA
HKA angle
Tibial slope
Femoral component
Tibial component
Computer Assisted Knee Arthroplasty
Conclusions and future challenges

• Yes, but…
• Stulberg (2008) : 40 knees with CAS vs 38 knees with conventional technique
• Follow-up : 2 - 4 years
• Functional results with CAS > convent. Techn. (KSS Score)

Stulberg SD, Yaffe MA, Gall Sims SE.
In Davies BL, Joskowicz L, Leung KS eds. Computer Assisted Orthopaedic Surgery
Computer Assisted Knee Arthroplasty
Conclusions and future challenges

• Dillon et al. (2008)
• Gait analysis on patients with CAS-TKR and patients with conventional technique.
• Adduction and extension moments (Newton/metre/kilo)
• Mechanical properties with CAS-TKR > conventional technique-TKR.

Dillon JM, Clarke JV, Nicol AC, Picard F, Gregori A, Kinninmonth A
Using gait analysis to compare functional outcome measures following total knee replacement performed with navigation or standard instrumentation techniques.
In Davies BL, Joskowicz L, Leung KS eds. Computer Assisted Orthopaedic Surgery
Computer Assisted Knee Arthroplasty
Conclusions and future challenges

- ease-of-use
- accuracy
- additional time
- additional material
- patient radiation, staff radiation
- intra-operative complexity
- pre-operative complexity
- access and approach
- MIS solution or not
- size of volume, etc...