# Roentgen Stereophotogrammetric Analysis (RSA)

Roentgen Stereophotogrammetric Analysis is a radiographic technique that allows micromotions (expressed as translations and rotations) between rigid bodies to be evaluated with a level of accuracy equivalent to 0.2 mm and 0.3 degrees. The flexibility of this technique has suggested its application in the field of biomechanics for studies related to skeletal system, such as stabilization and sinking of prosthetic implants, fracture stability, joint kinematics (shoulder, hand, spine, pelvis, hip, knee, ankle), cranium growth and ligament function (evaluation of knee laxity).

This technique includes 4 steps:

1. Markers implant. *During surgery phase markers have to be inserted in each segment of interest (for example prosthesis and surrounding bone). Markers are in tantalum (metal with a high atomic number, resistant to corrosion and biocompatible), and they have spherical shape and a diameter of 0.5 mm, 0.8 mm or 1 mm.*
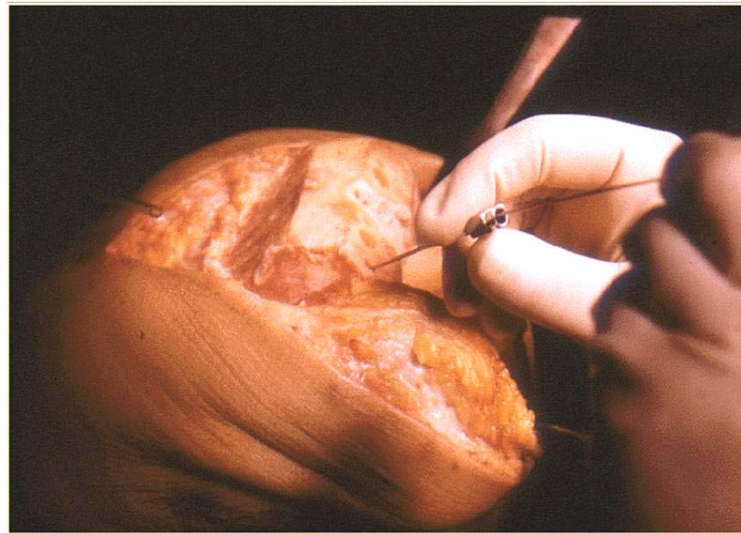

Insertion of markers

Tantalum markers

2. Radiographic exam. _The RSA technique requires the acquisition of two simultaneous radiographs from two different X-ray tubes, in order to obtain a three dimensional reconstruction of the anatomical region of interest. It is very important to acquire the two radiographs simultaneously, since a small movement of the knee between the two exposures can greatly affect the accuracy of the result._

example of acquisition; Frontal and lateral projections

To reconstruct the position of both roentgen foci a calibration box made of Plexiglas and with a polyhedric form is usually used .Its walls are provided with markers in a known position: those inserted in the walls closest to the radiographic film are called Fiducial Marks, while those inserted in the walls farthest from film are called Control Points.
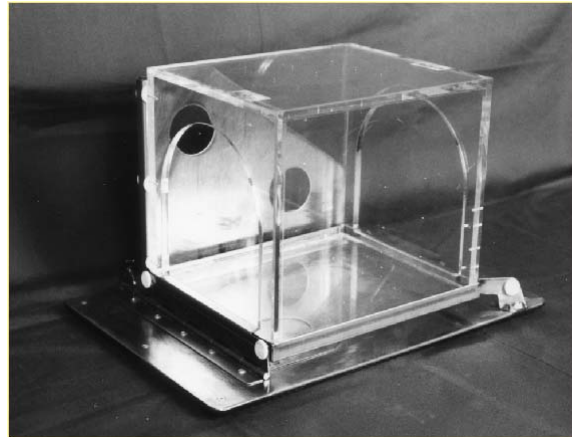
Cage used for small joints (biplanar set-up)

3. Data acquisition. *Radiographic data is acquired by specific software (RSA-CMS) able to identify, through dedicated algorithms, the cage markers (fiducial markers and control markers), the bone markers, and the prosthesis markers on RSA image. When the markers on RSA images are detected and their bi-dimensional coordinates are known, it is possible to calculate directly the 3D marker position by interpolating 2D data.*

4. Kinematics analysis. *On the radiograph, the segment of interest (prosthesis or bone) is defined by the markers implanted in itself. When three-dimensional positions of the markers are known, it is quite easy to calculate the barycentre of one segment of interest. The measurement of the movements during time of the barycentre of a rigid body compared with a second segment taken as reference.*

Rigid bodies constituted by markers

References

- *Garling, Kaptein, Geleijns, Nelissen, Valstar, "Marker configuration model based roentgen fluoroscopic analysis. Accuracy assessment by phantom tests and computer simulations", J. Biomechanics 2004.*
- *Valstar, Nelissen, Reiber, Rozing, "The use of Roentgen stereophotogrammetry to study micromotion of orthopaedic implants", J. of Photogrammetry and Rremote Sensing, vol. 56 (2002), 376-389.*
- *Valstar, de Jong, Vrooman, Rozing, Reiber , "Model-based Roentgen stereophotogrammetry of orthopaedic implants", J. Biomechanics Vol. 34, pp. 715-722, 2001.*
- *G. Selvik, "Roentgen stereophotogrammetric analysis", Acta Radiologica, Vol. 31, Fasc. 2, March 1990, pp.113-126.*
- *J. Karrholm, "Roentgen stereophotogrammetry. Review of orthopedic applications", Acta Orthop. Scand. 1989; 60(4): 491-503.*
- *G. Selvik, "Roentgen stereophotogrammetry. A method for the study of the kinematics of the skeletal system", Reprint from the original 1974 thesis, Acta Orthop. Scand. Suppl. No. 232, Vol. 60, 1989.*
- *L. Ryd, "Micromotion in knee arthroplasty. A roentgen stereophotogrammetric analysis of tibial component fixation", Acta Orthop. Scand. Suppl. No. 220, Vol. 57, 1986, pp. 22-36.*
- *L. Ryd, "Roentgen stereophotogrammetric analysis (RSA) of knee prostheses", Total knee arthroplasty, section XII, chapter 71, pp.1351-1366.*
- *SoaviR, Motta M, Visani A, "Variatio of the spatial position computed by Roentgen stereophotogrammetric analysis (RSA) under non-standard conditions", Med Eng Phys, 21(8),575-81, 1999.*