Preoperative planning of pelvic and acetabular surgery

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Computer program for preoperative planning of pelvic and acetabular fractures is presented. The program consists of three closely integrated tools, the 3D viewing tools, the segmentation tools and the reduction and fixation simulating tools. Data from CT of a fracture in DICOM format are used. First the 3D model is made, and then segmentation is carried out, where each fracture segment is made as an individual object. In reduction each fracture segment can be moved in all three directions, can be rotated in all planes and its pivot point of rotation can be changed. After reduction fixation can be undertaken, either with plates that can be automatically contoured or with pre curved plates that are already in program database. The plan of automatically contoured plates can be drawn and printed out in 1:1 scale. The most important is that all the steps can be carried out on a regular personal computer by the surgeon who is doing the preoperative planning. The program is used routinely for all pelvic, acetabular and difficult articular fractures at author's institution. First 22 cases were described. The presented computer program is an easily usable application, which brings significant value and new opportunities in clinical practice, teaching and research.

Pelvic and acetabular surgery is a demanding and challenging field of orthopaedic trauma surgery. Learning curve for this difficult surgery is long and it is difficult to obtain enough cases. For example, the mean number of acetabular cases per year per institution according to a German multicentre study is 17,9 (1). The goal of surgical treatment of disrupted pelvis is to restore anatomy and biomechanical characteristics (2) while the operative reconstruction of fractured acetabulum should follow the classical rules for articular fractures: anatomic reduction and stable fixation which enables immediate postoperative exercising. These general principles seem simple but in the case of pelvic and acetabular surgery imply some specific problems. Three dimensional anatomy of the pelvis is difficult to understand despite the use of modern diagnostic tools as 3D CT scans. Another problem is the choice of right surgical approach. It is impossible to see whole acetabulum or pelvis from a single approach. Good visibility is possible to a certain extent by using extensile approaches which are considered very extensive and traumatic and associated with numerous complications (3). After the approach, the reduction of bone fragments is difficult as well.

When manipulating large bone fragments, they are also being moved on the side that is often not visible during the surgical procedure. Direct visual control of joint surface is in majority of cases almost impossible. The intraoperative imaging is limited by two dimensional pictures of C-arm. The countering of implants is demanding as is the placement of the screws.

Taking all this into account, it is obvious that strict preoperative planning is a crucial step in pelvic and acetabular surgery. It is not therefore surprising that new technologies have been introduced in orthopaedics and trauma to help the surgeon to plan and to

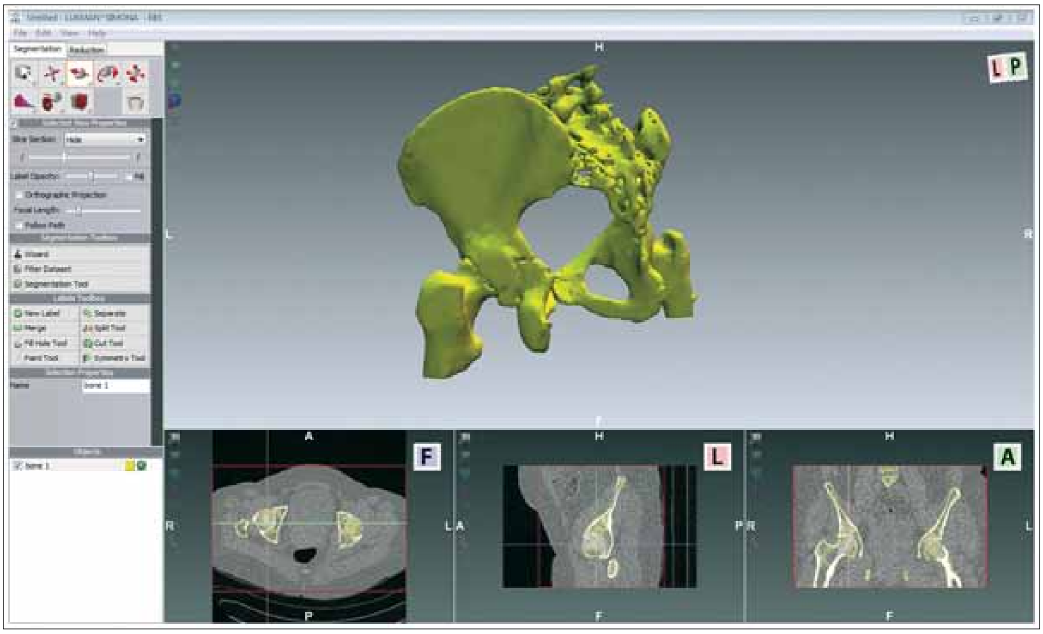

Figure 1: 3D model is made, it can be rotated and viwed from all perspectives. At the same CT images in different projections can be seen.

perform operative procedures more precisely. Computer assisted orthopaedic surgery (CAOS) has been developed as the application of computer based technology to assist the surgeon to improve the precision of the operative procedure (4). There are also reports on the use of virtual planning in the resection of pelvic bone tumours, for individual modelling of prosthetic substitutes and in maxillofacial surgery.

In 2005 we developed together with computer engineers from Sekvenca Inc. an experimental computer program which enables performance of virtual operation of injured pelvis (SQ PELVIS). The purpose of the software was to perform all the steps of the "real" surgical procedure on standard PC computer. The program was described in 2007 (5). The main problem of the program was segmentation process, which should be done by computer engineers and controlled by surgeons and radiologists. So we developed completely new software where all the steps can be performed by a surgeon (EBS software, Ekliptik ltd.).

Material and methods

We have used EBS software (Ekliptik ltd.). The program consists of three closely integrated tools, the 3D viewing tools, the segmentation tools and the reduction and fixation simulating tools. Data from CT of a fracture in DICOM format are used (1.5mm or 2.0mm slices). First the 3D model is made (Figure 1), and then segmentation is carried out (Figure 2, 3, 4), where each fracture segment is made as an individual object.

In reduction each fracture segment can be moved in all three directions, can be rotated in all planes and its pivot point of rotation can be changed. This enables more "real intraoperative" feeling of reduction (Figure 5,6).

Figure 2: ML view of segmented model.

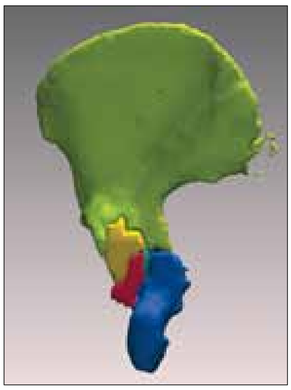

Figure 3: Posterior wall of acetabulum after segmentation is done.

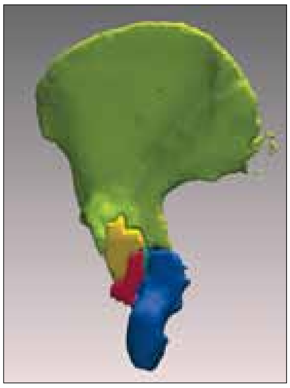

Figure 4: LM view of acetabulum after segmentation.

Figure 5: Reduced posterior wall of acetabulum.

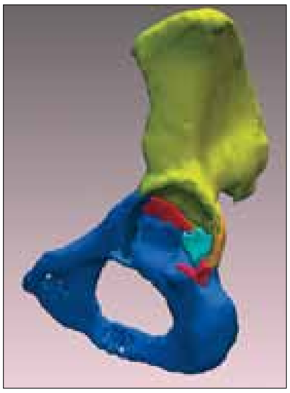

Figure 6: LM view of reduced acetabulum.

Figure 7: Simulation of fixation with reconstruction plates.

Figure 8: Simulation of X-ray view after reduction and internal fixation.

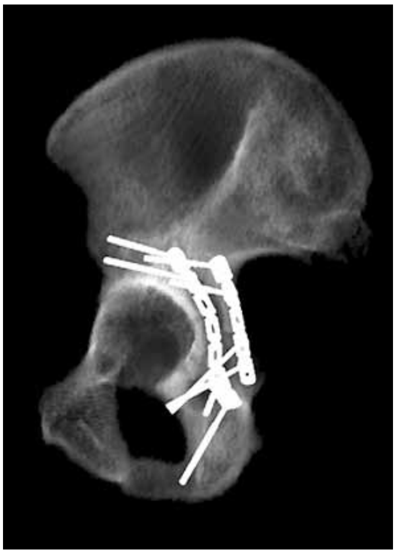

Figure 9: Obturator view after ORIF.

Figure 10: Iliac view after ORIF.

After reduction fixation can be undertaken, either with plates that can be automatically contoured or with precurved plates that are already in program database (Figure 7, 8).

The plan of automatically contoured plates can be drawn and printed out in 1:1 scale. Some specific "surgeons" needs functions were added: cut out function enables to cut out all the bone in any plane of the screw, so the exact position of the implant in the bone can be studied, virtual C arm enables to simulate intraoperative view and it is also possible to create any optional acetabular or pelvic fracture. All the steps can be carried out on a regular personal computer by the surgeon who is doing the preoperative planning. This is the complete novelty since segmentation can be carried out by the surgeon. In that way all the fracture lines are studied in 3D during segmentation process. The procedure is quick and easy. Now we use this program routinely in all acetabular and in most difficult articular fractures as well.

We also educated five surgeons to use the program independently. The learning time for the education was one half day course composed of theoretical and practical exercises.

Results

Until now we have used the program in 22 acetabular fractures. We used posterior (Kocher Langenbeck) approach in 10 cases, medial (according to Hirvensalo) in 4, iliomedial in 5 and combined iliomedial and posterior in 3 cases. We always performed the approach according to preoperative planning. We exactly followed the plan regarding the implants in 20 cases and made slight intraoperative changes in 2 cases. We never made major changes regarding the planned reduction and implants (Figure 9, 10).

The reduction was good to excellent in all 22 cases (step off less than 2 mm). All the surgeons found the program user friendly and described it as very advantageous in their daily practice.

Discussion

Computer technologies are relatively seldom used in everyday orthopaedic and trauma surgery practice. There are numerous reasons why the adoption of new technologies has been slower than expected. Computer technologies should make surgery easier and more precise but, on the other hand, these systems use a lot of new and costly hardware in the operating theatre and surgeons must be familiar with its use. So we tried to develop a simple and inexpensive system which can be used by any orthopaedic or trauma surgeon. In our new software all the steps can be easily performed by a surgeon: entering the DICOM data into the program, rendering, segmentation and virtual surgery. There is no need to any help from computer engineers. According to our experience the use of the program helps a surgeon to understand and to plan difficult pelvic and acetabular surgery. Good understanding of the fracture and well prepared preoperative plan can reduce intraoperative “surprises” to a minimum. It helps to choose the right operative approach and right implants. The educational possibilities of the software should also be emphasized. It is possible to build your own fracture types and help to understand difficult columnar theory of acetabular fractures. In the future the preoperative planning should be incorporated in the various navigation tools. There is also possibility to include biomechanical data and the precontoured plates can be produced custom made.

References

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