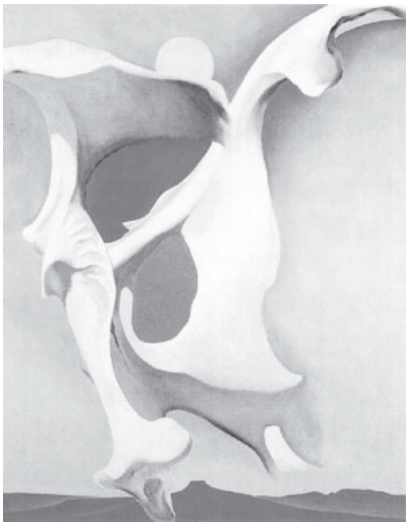
Chapter Eleven

Summary



SUMMARY

The aim of this thesis is to evaluate three major aspects of the use of sacroiliac screws in patients with unstable pelvic ring fractures: the optimal technique for sacroiliac screw fixation, the reliability of peroperative fluoroscopy and the late results. We focused on the questions whether sacroiliac screw fixation can be achieved safely by fluoroscopy, whether it is stable (for possible direct postoperative weight bearing) and if it improves the quality of life after pelvic ring fracture (or after nonunion of this injury).

In *chapter three* the functional outcome of internal fixation for pelvic ring fractures is described. Between January 1990 and September 1997 the charts of all patients treated with internal fixation for unstable pelvic ring fractures were reviewed retrospectively. All patients received a Short Form-36 health questionnaire and a form regarding functional result after pelvic trauma and were seen at the outpatient clinics. Of 26 men and 11 women, with an average age of 34.7, 31 returned the questionnaire and 28 patients were seen for physical and radiological examination. There were 16 type B and 21 type C fractures according to the Tile classification. Treatment consisted of various combinations of internal and external fixation. After an average follow-up time of 35.6 months the patients scored 78.6 out of 100 on the Majeed score. On the SF-36 scales physical and social functioning, role limitations due to physical problems and vitality were limited compared with the averages for the Dutch population. Patients treated with combined anterior and posterior internal fixation scored significantly better on both Majeed score and on several SF-36 categories, compared to patients with similar fractures treated with a combination of anterior internal fixation with external fixation. At the physical examination 39% did not have any abnormalities or complaints. 19 Patients (68%) were back at their original job. Although this was not a randomized study, patients with completely unstable fractures treated with combined anterior and posterior internal fixation had a better outcome compared to those treated with combined internal and posterior external fixation, but limitations in functioning, even after long term follow-up, persist.

Although little is known about the incidence of nonunion after pelvic ring fracture, it is often disabling for the patient. In *chapter four* research into the quality of life after fixation for nonunion is described. Eleven patients, operated between January 1990 and May 1999, were evaluated using the same scoring methods as described in chapter two and were asked whether surgery had improved their quality of life. In five patients the initial treatment consisted of internal or external fixation, the others were treated conservatively. Persistent pain was the main indication of nonunion in most patients. After (re)fixation most patients reported an improvement of the complaints although several patients still had limitations in physical functioning. Compared to the patients described in the previous chapter this group reported decreased physical role, vitality and general health on the SF-36.

In *chapter five to seven* several biomechanical experiments are described which focus on the optimal sacroiliac fixation technique for various fractures. In order to determine stability of various sacroiliac screw fixations cadaveric pelves were loaded and using a 3-dimensional video system, stiffness and the load to failure were investigated.

No other study has examined the number of sacroiliac screws and their position into the sacral vertebral body required for optimal fixation. In *chapter five* this was tested in twelve pelves with a Tile C fracture. In order to limit the influence from an anterior fixation we used isolated posterior fixation and loaded both hemipelves separately for baseline measurements. After a fracture was created each side was fixated with one of the following methods: one sacroiliac screw in the first sacral body, two screws converging in the first sacral body or a technique with one screw in the first and one in the second vertebral body of the sacrum. The stiffness of the intact posterior pelvic ring proved superior to any screw technique. Significant differences were found for the load to failure and rotation stiffness between the techniques with two screws and a single screw. No significant differences between the techniques with two screws were found. The addition of a second screw seems to prevent rotation and improves the load to failure.

In *chapter six* we examined whether the stability of partially unstable pelvic fractures (open book fractures) can be improved by combining plate fixation of the symphysis with a sacroiliac screw posteriorly. Six cadaveric pelves were therefore loaded with and without fracture to 300 N, thus avoiding failure levels, and subsequently up to 700 N. None of the measured parameters were significantly different for the techniques with or without sacroiliac screw or compared to the intact situation. Load to failure was only reached in one of the six cases. In all other cases the fixation of the pelvis to the frame failed before failure of the fixation itself. In these cases a load of about 1000N or more could be applied. This suggests that, even without sacroiliac screw fixation, these pelves can withstand even higher forces and it seems safe to undertake a clinical study into direct postoperative weight bearing.

In *chapter seven* we investigated completely unstable pelvic fractures that we fixated both anteriorly and posteriorly under cyclic loading conditions in order to simulate weight bearing. We compared the intact situation to anterior plate fixation combined with one or two sacroiliac screws for a Tile C1 fracture in twelve specimens. In 2000 measurements each pelvis was loaded with a maximum of 400N. The stiffness of the fixation with two screws was 59% and 44% of the intact pelvis for translation and rotation stiffness respectively. No difference in translation or rotation stiffness was found between the techniques with one or two sacroiliac screws. However, a significantly higher load to failure and significantly more loading cycles before failure could be achieved using two sacroiliac screws compared to one screw. A better grip of the screws was a significant predictor of a longer endurance of the fixated pelvis during loading. Although the combination of anterior plate fixation combined with two sacroiliac screws is not as stable as the intact pelvis, embalmed aged pelves could be loaded repeatedly with physiological forces. The fact that the average trauma patient is younger and that the quality (or grip) of the fixation was a significant covariable for longer endurance of the fixation, suggests that for adequately fixated completely unstable fractures direct weight bearing can be examined clinically.

Fluoroscopic placement of guided sacroiliac screws is a well-established method of fixation of the posterior pelvic ring. The main problem still remains the risk of neurological injury due to the penetration of the intervertebral root or the vertebral canal. In *chapter eight and nine* we examined the peroperative fluoros-

copy. First we compared the peroperative position of the screws with the more accurate postoperative C.T.. Charts and radiographs (peroperative fluoroscopic views, postoperative radiographs and C.T. scan) from 88 patients, in whom the posterior pelvic ring was stabilized for several indications, were reviewed retrospectively. Seven of the 88 patients had neurological complaints and were reoperated. All complaints resolved completely and no permanent neurological damage occurred. Positioning both sacroiliac screws in the first vertebral body had a significantly lower rate of neurological complaints compared to positioning the lower screw in the second vertebral body. Malpositioning on C.T. scan correlated most accurately with neurological complaints, while no correlation between peroperative position and neurological deficit was found. 285 screws were reviewed and, depending on the type of imaging (X-ray or C.T. scan), 2.1% to 6.8% of the screws showed malpositioning. In several cases the malpositioned screws did not cause any complaints. Postoperative radiographs did not show to have any additional value above peroperative radiographs. It seems that percutaneous sacroiliac screws can be positioned safely without permanent neurological injury.

Several improvements to the technique described in the previous chapter were made in order to limit the incidence of postoperative neurological damage. The most important was the introduction of a lateral view in addition to inlet and outlet views. To investigate the importance of the lateral view the charts and radiographs of 74 patients were reviewed in *chapter nine*. On peroperative radiographs and postoperative C.T. scan positioning was scored for 222 screws and compared to clinical results. Three patients reported neuralgia or sensory deficit, which seemed to be caused by malpositioning of the sacroiliac screws. Malpositioning could be seen on C.T. and could be suspected on fluoroscopy retrospectively. Most common form of malpositioning was that one of the lower screws was positioned too posterior on the ilium causing intrusion into the sacral canal or foramina. All complaints improved after removal of the screws and no permanent injury was seen. Overall, about 92% of the screws were positioned intraosseously without intrusion into any vital structure. Most of the malpositioned screws did not cause any complaints. The lateral view proved to be a significantly more accurate predictor on the dorsoventral and the craniocaudal position of the sacroiliac screw than inlet view or outlet view. Although the lateral view remains a difficult view because of the necessity to reposition the C-arm in order to verify the correct position and the increased fluoroscopy time, the lateral view offers increased safety and may prevent malpositioning of sacroiliac screw and neurological deficit.

Concluding, pelvic ring fractures remain a complicated injury. Sacroiliac screw fixation is a technique that has several advantages. Compared to plate or external fixation it allows a stable fixation without extensive wounds that in laboratory results seems stable enough to examine postoperative weight bearing clinically. Despite the fact that neurological injury due to penetration of the screw into the intervertebral foramen still is possible, the addition of the lateral view seems to limit this risk and future techniques such as C.T. guided positioning or robot insertion might decrease the incidence of this complication even further. However even with the current technique no permanent neurological impairment was seen. Finally, combined posterior and anterior fixation seems to improve the quality of life of patients with pelvic ring fractures and with nonunion of the pelvis.