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STABILITY OF OSTEOSYNTHESIS IN HIP ARTHRODESIS

By

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The ultimate purpose of metallic fixation for hip arthrodesis is to achieve primary stability, to avoid plaster immobilization and to shorten the period of recumbency.

Various techniques have been suggested and different types of appliances have been available.

In order to determine the degree of immediate fixation that different operating procedures could produce experiments were performed on fresh autopsy material.

Before we could systematize our experiments the problems concerning hip joint stability were analyzed in terms of factors which might influence the immediate results of osteosynthesis. In a series of orientating experiments it became obvious that the fixation obtained was at least related to the following conditions:

1. Surface contact with regard to size, shape of the joint area and diastasis.
2. Type of metallic appliance.
3. Physical properties of the bone in which the metallic fixation was inserted.

TECHNIQUE OF EXPERIMENTS

Fresh autopsy material consisting of a hemipelvis including the hip joint and the upper part of the femur were dissected from fresh cadavers, a few hours after death. The specimens were left with some soft tissue including the capsule and the ligaments of the joint. Care was taken to avoid drying of the specimens since pilot studies have shown that the physical behaviour of bone is different in dry and wet specimens.



Fig. 1.

Osteoarthritis of the hip. The incongruence of the articular surfaces seen in the central portion.

The pelvic portion was fixed according to the anatomical planes to a stable wooden construction by means of plastic glue (Plastic Padding) and screws in such a manner that the specimens could be handled "surgically".

Metallic implants of different types, consisting of three flanged nails, screws of different constructions, pins of the Steinman-type, or thin nails of the Nyström-type were then applied, transarticularly fixing the femoral head to the acetabulum. The osteosynthetic material was applied under X-ray control with surgical technique and in such a way that the joint was never opened.

SURFACE CONTACT

The contact between the surfaces was studied first by radiographs and later by anatomical measurements. The latter were made after the specimens had been sectioned. Adequate surface contact can only be obtained if the surfaces are congruent. In joints where deformities are affecting the femoral head or the acetabulum, the amount of diastasis

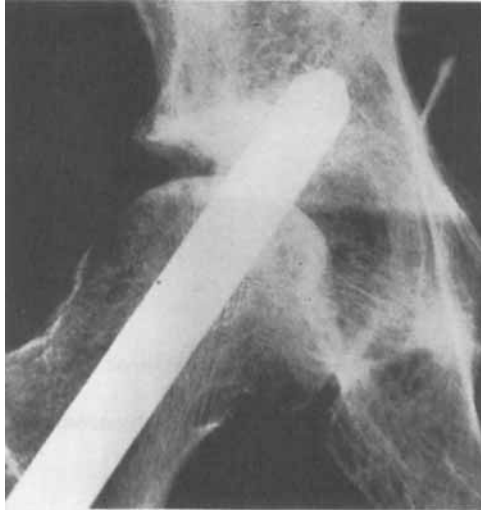


Fig. 2.

The three-flanged nail penetrating the acetabulum forces out the femoral head, causing a diastasis.

will increase if the incongruent surfaces are placed in certain positions (Fig. 1).

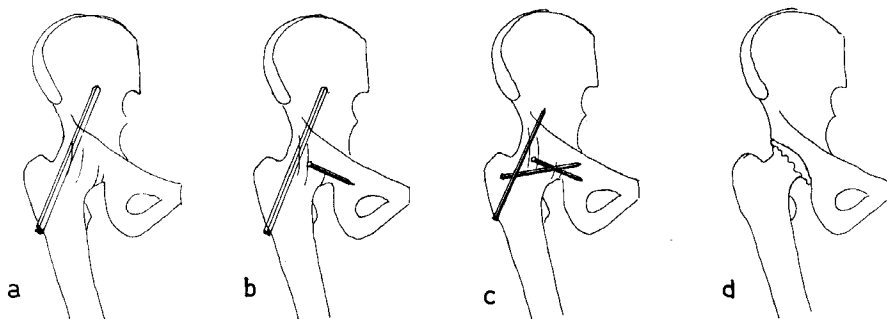
Diastasis will also occur when metallic implants are introduced through the joint. This is especially true in arthrotic hips where the acetabulum is much harder than the femoral head. The variations in resistance to the passage of the implant is one cause of diastasis (Fig. 2).

When a nail is used diastasis increases with its size and bluntness. With screws it is correlated to shape of the tip, type, number and distance between the threads.

In order to avoid diastasis with these types of implants the material to be penetrated can be drilled. To a certain extent diastasis can be decreased or partly eliminated if the femoral head is kept pressed against the acetabulum while the nail is driven in with sharp blows of the mallet.

Thinner nails of the Steinmann or Nyström-types have better penetrating ability and the smaller size will also cause less diastasis.

Screws which are threaded only at the end will also help to avoid diastasis because they will add a compressive force between the surfaces when the threaded portion is anchored in the acetabulum.

*Fig. 3.*

Drawings which show the four methods of arthrodesis used experimentally.

- a) one three-flanged nail.
- b) one three-flanged nail + one Nyström-nail.
- c) three Nyström-nails.
- d) Plastic-Padding.

METALLIC APPLIANCES

Metallic implants were introduced transarticularly under X-ray control, without opening the capsule and ligaments, when it was determined that the surfaces were in good contact. First one single three-flanged Smith-Petersen-nail was tested. The nail was inserted in various controlled positions both with regard to direction and to depth in the ilium. If the nail is driven in the direction of the sacro-iliac joint a maximum depth is obtained (Fig. 3a).

The stability was measured in a specially constructed apparatus (Fig. 4). As seen from the diagram the femoral shaft was pulled in various directions and the deflection was measured by a dial indicator with an accuracy of 1/100 mm.

Diagram number 5 illustrates the amount of movement occurring when the femoral shaft is pulled in the direction of flexion, abduction, and adduction with a step-wise increasing force. The diagram shows that the stability was less in flexion, better in abduction and in adduction. This is due to the fact that the axis of movement in flexion is close to that of the nail. Nails introduced in the long axis of the neck into the centre of the acetabulum offer almost no stability at all, because of the thinness and weakness of the acetabular floor.

In order to improve stability, one Nyström-nail was inserted in an antero-posterior direction. Note that on the X-ray drawing (Fig. 3b) the Smith-Petersen-nail had an oblique direction, while the Nyström-nail had almost a horizontal direction (60–70° of difference).

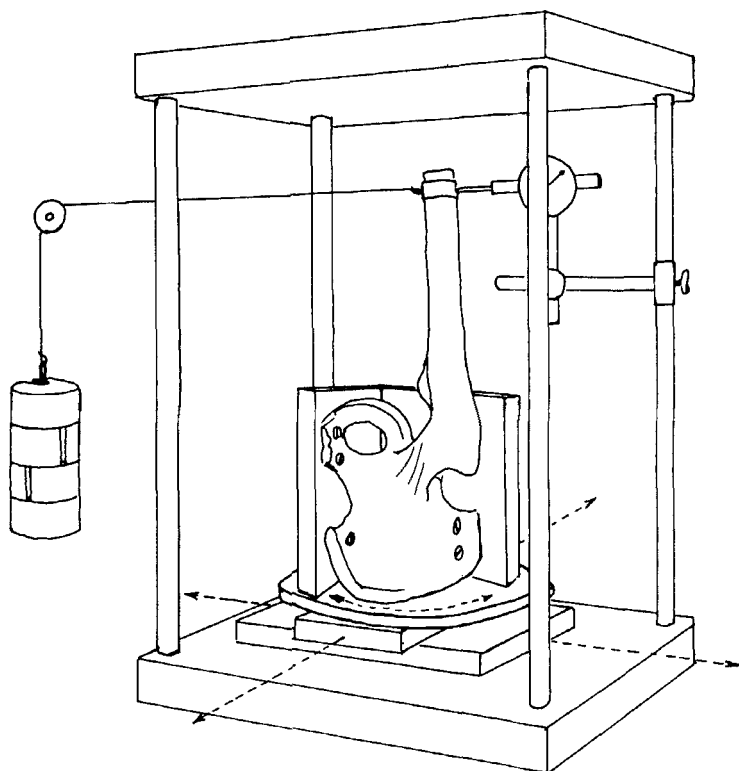


Fig. 4.

Experimental model, used to test the stability of the arthrodesis.

In these cases the stability improved for all tested movements (Fig. 5). Flexion was no longer possible to the same extent as when the same specimens only had a Smith-Petersen-nail. The stability was also better in abduction and adduction. Adduction was best protected but the improvement was greatest for attempted flexion.

In the next series of experiments the Smith-Petersen-nail was removed and two Nyström-nails inserted towards the ilium and pubis (Fig. 3c). The stability was now even better. This was a function of the increased holding area as is shown in Fig. 6.

Finally, in order to evaluate the amount of stability, comparisons were made with the same specimens after an experimental intra-articular arthrodesis was performed with plastic glue (Plastic Padding). The glue was introduced between the joint surfaces after the cartilage had been removed (Fig. 3d). This type of fixation gives the maximum stability that can be obtained in an autopsy hip joint.

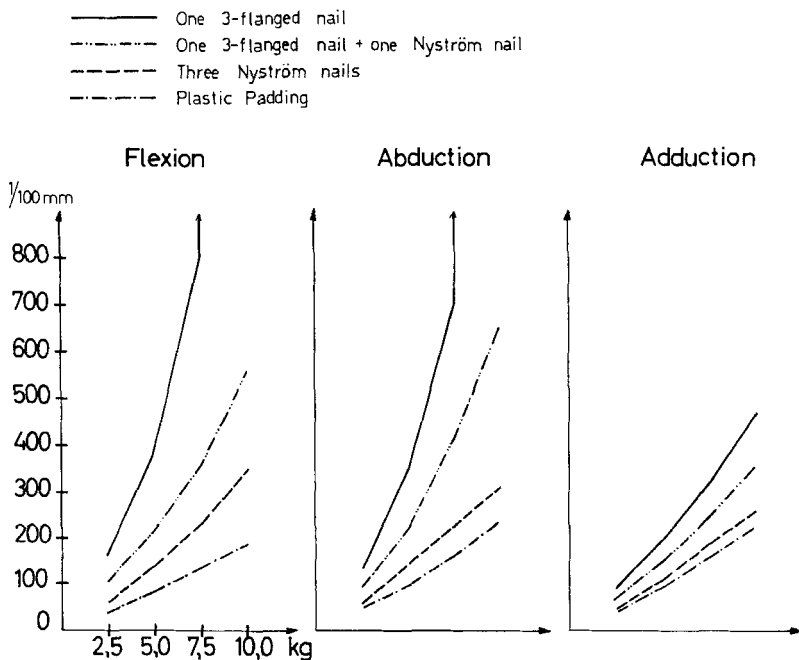


Fig. 5.

Stress-strain diagrams which show the difference in stability for the four tested methods of arthrodesis.

The curves now obtained represent the elasticity of the bone and apparatus.

So far screws have not been checked for stability.

In none of the experiments was plastic deformation of the osteosynthetic material noted.

The amount of stability obtained with different types of osteosynthesis varies not only with the metallic implants, but also with the strength and architecture of the bone. The correlation between the position of the nail with regard to the bony architecture was also studied. Experiments were also performed using a Smith-Petersen-nail first driven through one cortical layer a specific distance, into cancellous bone and then tested with regard to resistance against force. Subsequently it was brought through a second layer of cortical bone and the test, now repeated, showed increased stability (Fig. 7). Furthermore, the amount of bone tissue in which the nail was anchored improved the stability of the construction.

It is obvious that stability depends on many variable factors in bone

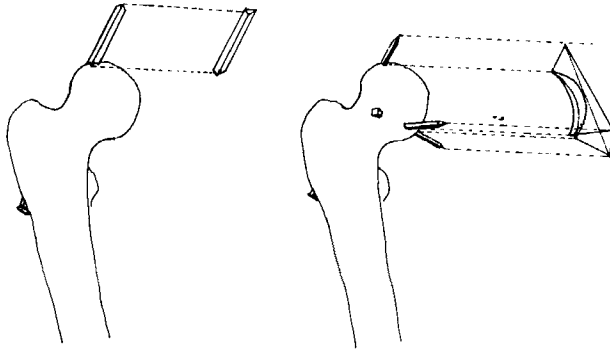


Fig. 6.

The fixed area is increased when three Nyström nails are used.

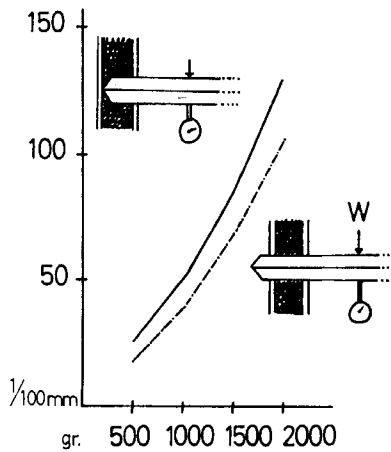


Fig. 7.

Increased stability is obtained when the nail is driven through two cortical layers.

(thickness of the cortical bone, degree of osteoporosis, presence of bone defects, cysts, fractures etc.)

CONCLUSIONS

These experiments illustrate that the Smith-Petersen-nail in hip arthrodesis offers incomplete stability of the femur in respect to the pelvis, regardless of the direction of the nail.

If one Nyström-nail, introduced in an antero-posterior direction, is added the stability is improved. Three thin Nyström-nails introduced in direction of ilium, pubis and ischium, through the femoral neck and

head, offer still more stability, approaching that obtained in artificial fusion of the hip made by plastic glue.

In addition to the results of our experiments, it can generally be stated that a large nail needs a great force to be introduced, produces considerable distraction, and increases the risk of fractures and diastasis.

The use of three thin Nyström-nails properly inserted diminishes the disadvantages mentioned and offers better primary stability.

SUMMARY

An experimental investigation was carried out with autopsy material on the primary stability of hip-joint arthrodesis as performed with different osteosynthetic techniques. Three thin nails of the Nyström type give better primary stability than fixation with one three-flanged nail.

RESUME

Une enquête expérimentale a été effectuée sur un matériel d'autopsie concernant la stabilité primare de l'arthrodèse de l'articulation de la hanche au moyen de différentes techniques ostéosynthétiques. Trois clous minces du type de Nyström donnent une meilleure stabilité primaire que la fixation avec un clou à trois ailettes.

ZUSAMMENFASSUNG

Eine experimentelle Untersuchung an einem Autopsie-material über die primäre Stabilität von Hüftarthrodesen, die mit verschiedenen osteosynthetischen Techniken ausgeführt wurden, wird vorgenommen. Drei Nägel der Nyströmtype ergeben bessere primäre Fixation als die Anwendung eines einzigen Nagels mit drei Lamellen.

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