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Biomechanical Effects of Innominate Osteotomy

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Summary

The simple pelvic osteotomy in the technique of SALTER was simulated on a macerated female pelvis. The effect of tilting the distal segment of the pelvis outwards, forwards and downwards with different osteotomy angles in the range between 0 and 40° was examined. Depending on the angle of osteotomy, the angle of rotation and the amount of the displacement of the distal segment of the pelvis were measured as well as the CE angle. The data thus ascertained give the operator planning parameters with whose help he can preoperatively estimate the remaining hip parameters depending on the desired improvement of the acetabulum.

Preface

Since SALTER in 1961 reported about the innominate osteotomy which he himself had developed, this method has become one of the most widely-used operations to improve the acetabulum in the treatment of hip dysplasia. The method of operation consists of a dividing of the os innominatum on the level of the spina iliaca ventralis inferior, and a tilting of the acetabulum in the lateral, and a tilting of the acetabulum in the lateral, ventral and distal directions, a wedge-shaped opening of the osteotomy site and securing of the displacement by a wedge-shaped bone graft. In comparison the compound osteotomies (LE COEUR 1865, WAGNER 1965, HOPF 1966, SUTHERLAND 1972, STEEL 1973 and TÖNNIS et al. 1981, TÖNNIS 1982) which, like SALTER's simple osteotomy, have the aim of enlarging the angle of rotation of the acetabulum in the lateral and forward directions, the innominate osteotomy is a smaller operation. It must be said, however, that this simple pelvic osteotomy leads to changes in the biomechanics of the hip joint and to a deformity of the pelvis. Biomechanical experiments as to the extent of the changes in relation to the achieved improvement of the acetabulum have not as yet been carried out. For the planning of the operation, the estimation of the operation result and the assessment of the post-operative pelvic deformity, we held it desirable to have data at our disposal, which would allow conclusions about the changes in the acetabulum and the pelvis due to the operation.

Key words: Innominate osteotomy (Salter), Symphyseal distance, CE angle.
索引語：寛骨骨切り術，恥骨間距離，CE 角.
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Materials and Methods

The examinations of the simple SALTER pelvic osteotomy were carried out on a macerated, normally developed, natural female pelvis. The macerated femur belonging to this pelvis were centered in the acetabulum with 5° external rotation. The symphyses was fixed on the centre of the pubic bone with a wire nylon suture.

An osteotomy according to the instructions of SALTER (1961, 1966, 1976, 1982) was carried out in the middle of the spina iliaca anterior inferior in a straight line with the Incisura ischiadica. A thin notch was phased in the thus formed surface of the distal segment, which was level in the cranial plane, a thin groove was phased in a line from the spina iliaca anterior inferior to the incisura ischiadica, in which chrome wire was laid. The same marking was made on the caudal surface of the upper pelvic segment analogically.

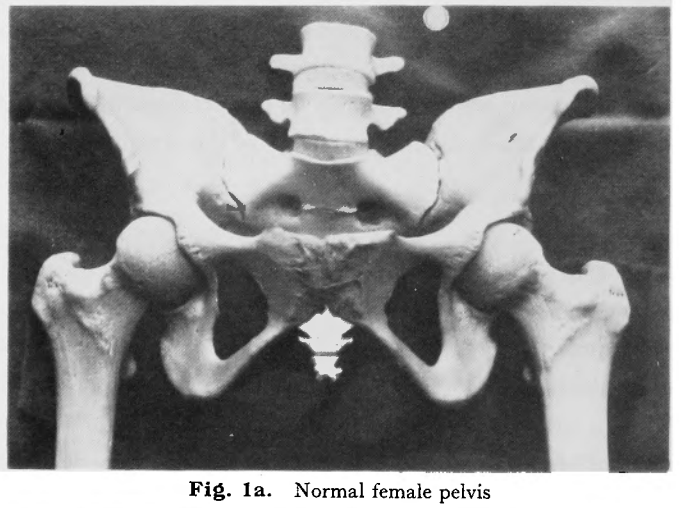

Fig. 1a. Normal female pelvis

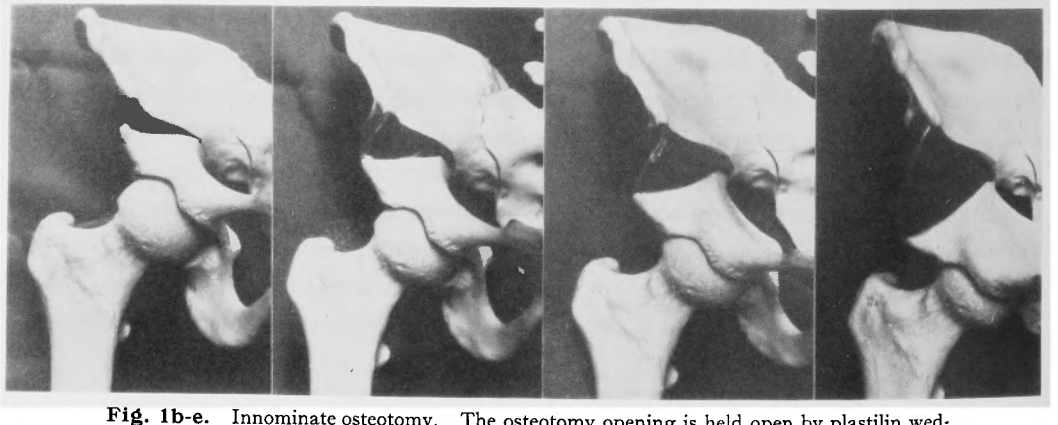

Fig. 1b-e. Innominate osteotomy. The osteotomy opening is held open by plastilin wedges of 10°, 20°, 30° and 40°
The tilting of the acetabulum outwards and forwards is clearly recognisable by the increasingly better coverage of the femoral head. The distal displacement of the hip joint (lengthening of the leg) is distinct.

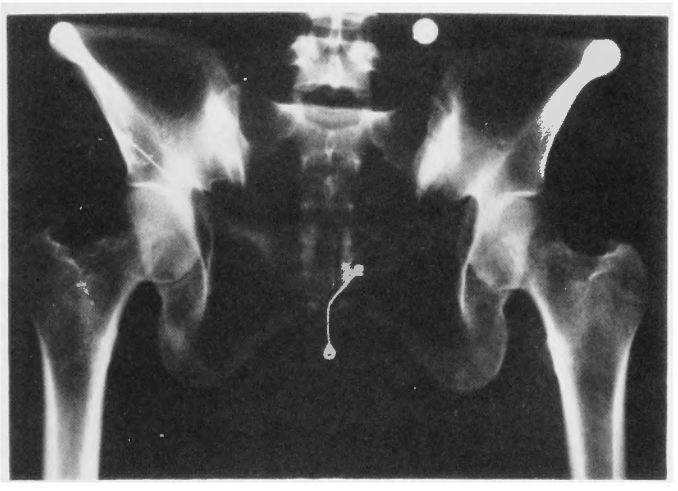

Fig. 2a. The X-ray finding of a.p. pelvis of the sample.
The wire marking of the innominate osteotomy is recognisable, also the securing of the symphysis.

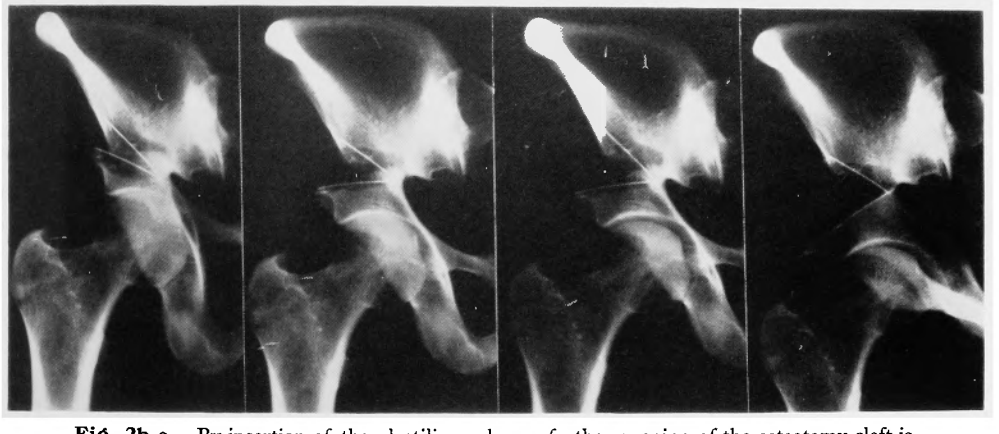

Fig. 2b-e. By insertion of the plastilin wedges a further opening of the osteotomy cleft is achieved. The measuring of the virtual angle of osteotomy and the lateralization of the acetabulum is made possible by the two wire markings. The lowering of the femoral head should be noticed.

This made a better X-ray presentation of the osteotomy wedge possible (Fig. 3). The osteotomy was then opened on the ventral, lateral and caudal, whereby care was taken that corticalis lay on, corticalis in the area of the incisura ischiadica. The respective osteotomy angles were held by pre-formed plastilin wedges, which allowed X-rays to pass through at 10°–20°–30°–40° (Fig. 1). The angles of tilting and rotation to lateral resulted from the fixed turning point in the area of the symphysis.

In each of the given osteotomy angles an a.p. pelvis X-ray in the Bucky table technique was made with a fixed focus-film-plate distance of 1 m. The following *virtual measurements* could be determined in the X-ray plates:

1. The angle of osteotomy α' formed by the chrome wire lines (Fig. 3, 5).

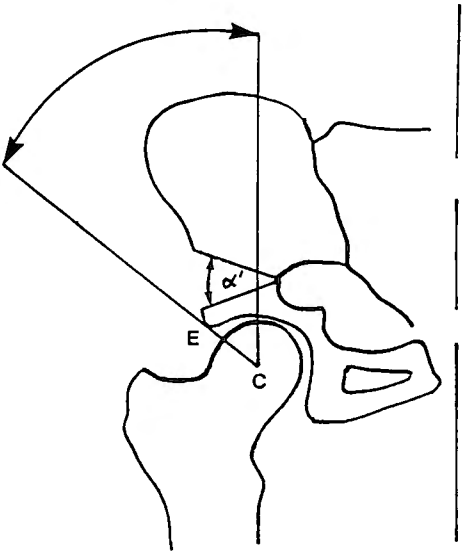

Fig. 3. Measuring of the CE angle of WIBERG and the virtual angle of osteotomy α'.

2. The CE-angle of WIBERG (1939) as the extent of the femoral head coverage (Fig. 3).
3. The lateralization of the acetabulum L.
   For this, the plump-line was held from the spina iliaca anterior inferior of the proximal segment in the direction of the distal osteotomy surface marked by the chrome wire. The distance between the point of interresection of the plump line with the distal osteotomy plane and the spina iliaca inferior of the distal pelvic segment was taken as

Fig. 4. Measuring of the lateralization "L" of the acetabulum.

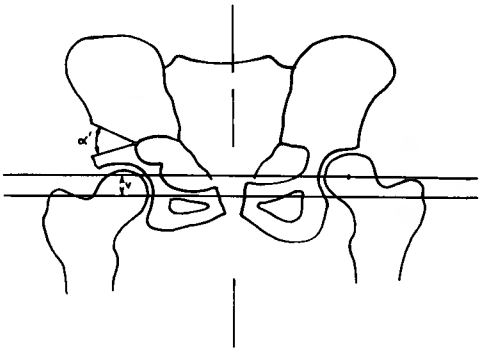

Fig. 5. Measuring of the distal displacement "v" of the hip joint: A straight line is drawn through the centre of the femoral head in both the operated and nonoperated sides. The distance between these two parallels "v" is the gauge for the distal displacement of the operated hip joint.

the expression for the lateralization of the acetabulum (Fig. 4).

4. The distal displacement of the hip joint in the cranial—caudal direction "v". It is determined as the distance between the two parallels drawn through both femoral head centres at right angles to the body axis (Fig. 5).

According to the arrangement of experiments the following real values could be ascertained on the osseous pelvis.

1. The angle of osteotomy α by the given osteotomy wedge (Fig. 6).
2. The angle of rotation in the horizontal plane β, whose sides were formed by the chrome wire marking in the upper and lower segments of the pelvis (Fig. 6).
3. The distance "d" between the upper symphyseal edges of the pubic bones (Fig. 6).

Results

The osseous pelvis is sufficient for the purpose of comparison with the data which are to be found operatively, as, in osseous—ligamentous pelvic specimen, the rigidity of the ligament apparatus prevents displacement and torsion, and no elasticity of the symphysis can be found in

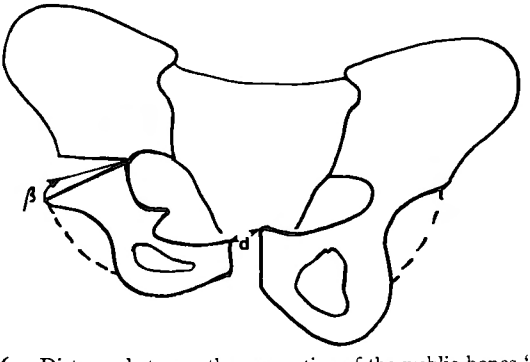

Fig. 6. Distance between the upper tips of the public bones "d" Horizontal angle of rotation β.

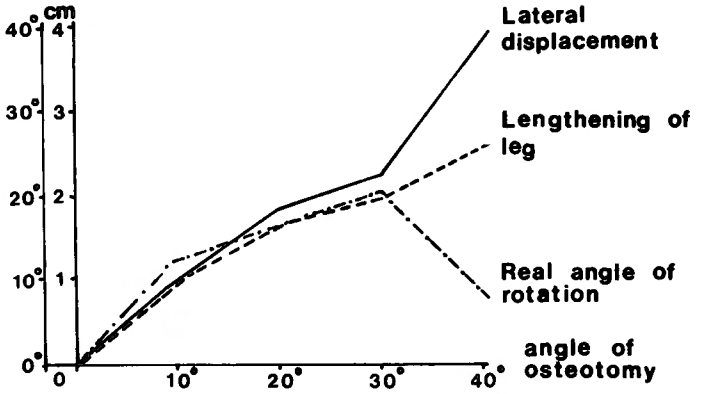

Fig. 7. Development of the lateral displacement, of the lengthening of the leg and of the real angle of rotation.

corpes (HOPF 1966).

1. Lengthening of the leg

With an increasing angle of osteotomy, there is a continual lowering of the hip joint. The consequence is a lengthening of the leg on the operated side. With a real osteotomy angle of 30° (corresponding to a virtual osteotomy angle of 50°) is amounts to 1.9 cm (Fig. 7).

2. Symphyseal distance

The distance between the upper symphyseal edges of the pubic bones "d" exhibits a slow increase up to 1.9 cm, which is dependent on the enlargement of the osteotomy angle up to 30°. When the osteotomy angle is increased to 40°, the distance between the symphyses increase to 3 cm (Fig. 8).

3. Lateral displacement

The lateral displacement of the acetabulum also exhibits a gradual rise from 0 to 2.2 cm in the zone of a real osteotomy angle of between 0 and 30°. If the osteotomy angle is opened up to 40°, the lateral displacement rises very steeply (Fig. 7).

4. Angle of osteotomy

The value of the angle of osteotomy α' determined in the X-ray plates is significantly higher

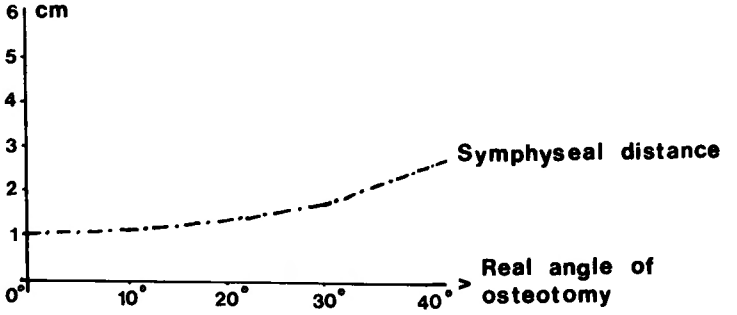

Fig. 8. Development of the distance between the public bones "d".

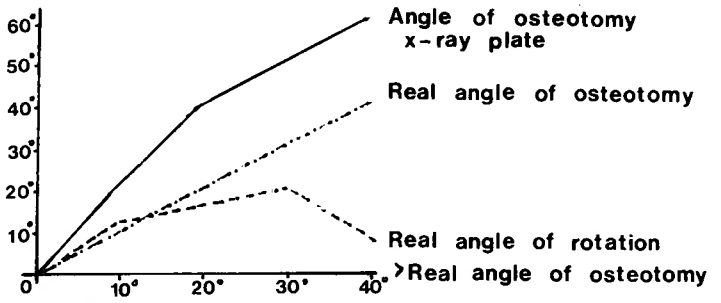

Fig. 9. Development of the real and virtual angles of osteotomy and of the real angle of rotation.

than that of the real angle of osteotomy. This is especially valid for real osteotomy angles of up to 30° In this zone, the values of the virtual osteotomy angle lie up to 100% higher than those of the real osteotomy angle (Fig. 9).

5. Angle of rotation

The real angle of rotation, around which the distal segment of the pelvis swings outward, rises gradually up to an osteotomy angle of 30°, and then falls steeply (Fig. 7, 9).

6. CE-angle

The CE angles exhibit an even increase of about 2/3 of the original value in osteotomy angles of up to 30° With an enlargement of the real osteotomy angle to 40°, a steep rise in the CE angle of a further 2/3 of its original value occurs (Fig. 10).

Discussion

The improvement of the abnormal acetabulum is achieved in SALTER's innominate osteotomy by tilting the acetabulum outwards, forwards and downwards. This movement takes

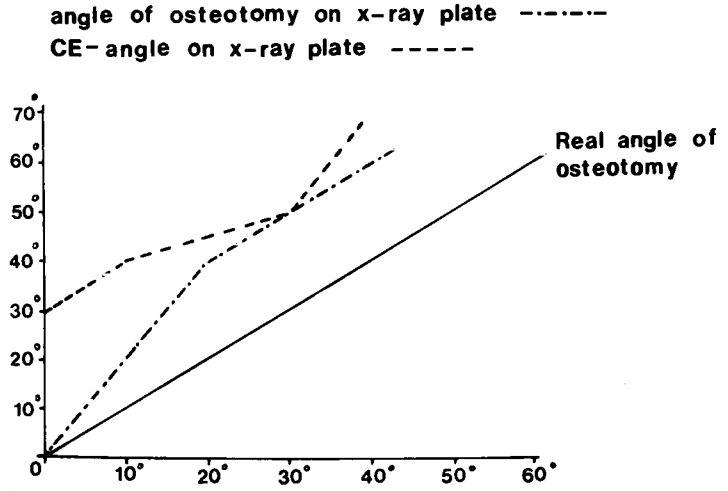

Fig. 10. Development of the virtual angle of osteotomy and of the CE angle of WIBERG.

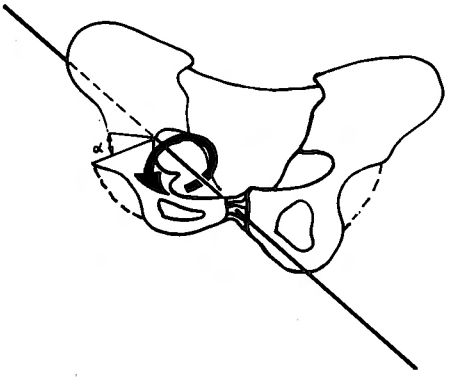

Fig. 11. With the opening of the osteotomy cleft (α) the acetabulum is tilted outwards, forwards and downwards. This movement is carried out around a diagonal axis between the symphysis and the vertex of the wedge-shaped osteotomy opening in the area of the incisura ischiadica.

place around a diagonal axis between the symphysis and the vertex of the osteotomy opening in the area of the incisura ischiadica. The acetabulum is turned around this axis. (Fig. 11).

As may be seen from our examination of the angle of rotation, the lateral summit of the circular movement is reached when the real angle of osteotomy is 30°. Whilst the CE angle exhibits a continual rise of about 2/3 of the original value when the angle of osteotomy is up to 30°, it rises sharply when the angle of osteotomy increases from 30° to 40°. This phenomenon of a sudden rise also occurs in the extent of lateralization, the distal displacement of the hip joint (lengthening of the leg) and again for the extent of the symphyseal distance (Fig. 7, 8).

If the lateral segment of the pelvis were turned further, a decrease in these values could be reckoned with. This further turning is however not practically possible owing to the tearing of soft parts which would inevitably result.

The displacement of the acetabulum to lateral and distal means in clinical practics that a strongly increased tension of the soft parts of the pelvis must be reckoned with in osteotomy angles of over 30°. This has significance for the intra-articular pressure of the hip joint, which SALTER tries to reduce by adductor tenotomy and intrapelvic iliopsoas release. A further limiting factor is the elasticity of the symphysis. According to KIRCHHOFF (1982), a stretching or torsion of the symphysis in a child or a grown-up of up to 1 cm is possible. This correspondends to the symphyseal distance which is reached when the real osteotomy angle is 30°. An opening of the osteotomy beyond this point would automatically lead to a rupture of the symphysis. The real angle of osteotomy of 30°. which corresponds to a virtual X-ray angle of osteotomy of 50°, thus represents a borderline which ought not to be crossed in clinical practice. Up to this borderline we can observe an increase in the CE angle of up to 20° a fact which underlines the efficiency of the method as far as improvement of the acetabulum is concerned. Even taking into account that extremely shallow acetabula are not an indication for SALTER innominate osteotomy we can still state, that using a real osteotomy angle of up to 30° we can correct extremely abnormal acetabula by this method. Since the tilting of the acetabulum to lateral, ventral and

distal inevitably leads to an increase in intra-articular pressure in the hip joint, thus causing a lengthening of the leg and a stretching of the symphysis, the tilting of the acetabulum should stop, when the acetabular roof completely covers the femoral head in the weight-bearing part. In this way we can reduce the unwanted side-effects caused by the tilting of the acetabulum to the necessary minimum and at the same time achieve an optimum enlargement of the pressure-bearing zone.

For practical purposes, the values of the CE angles measured by us in the clinically relevant field of real osteotomy angles of up to 30° as well as the angle of rotation, lateralization of the acetabulum and lengthening of the leg give the operator planning data, with whose he can pre-operatively estimate the remaining hip parameters depending on the desired improvement of the acetabulum.

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和文抄録

寛骨骨切り術の生体力学的効果についての研究

Würzburg 大学整形外科学教室（主任：A. Rütt 教授）
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成人女子の骨盤標本を用いて Salter による寛骨骨切り術を行った．骨切り角 0°～40° による骨切り部の末梢側骨盤の外方・前方・下方への傾斜の程度について計測し，検討を加えた．

それによると骨切り角の増減によって末梢側骨盤部の回旋角や外側移動度に変化が生じ，さらには恥骨間距離，下肢長，CE 角などに変化がみとめられた．臼蓋を傾斜させることによって下肢の延長，恥骨結合部の異常な開大，股関節内圧の上昇などをひきおこすことがわかり，術前プランニングにはこの点を充分に考慮すべきであることがわかった．