A Biomechanical Comparison between Salter Innominant Osteotomy and Pemberton Pericapsular Osteotomy

Salter İnnominate Osteotomisi ve Pemberton Perikapsüler Osteotomisi Arasında Bir Biyomekanik Karşılaştırma

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Abstract

Objective: This study aims to compare the pelvic biomechanics of patients who underwent Salter innominate osteotomy (SIO) for one hip and Pemberton pericapsular osteotomy (PPO) for the other hip.

Materials and Methods: Fifty-seven of 126 patients who received a one-stage procedure involving SIO for one hip and PPO for the other hip were included in this series. Preoperative x-rays, archived reports and patient recall were obtained and retrospectively analyzed for these 57 patients. Pelvic biomechanics of the two osteotomy techniques were compared on x-rays and computerized tomography imaging.

Results: Based on x-rays, three hips with SIO and 1 hip with PPO had changes that could reflect unstable pelvic biomechanics. SIO caused an average lower limb discrepancy of 0.47 cm in all patients. Positive results were found in 5 patients at their most recent clinical examination.

Conclusion: PPO affects the biomechanics of the pelvis much less than SIO. PPO demonstrated ideal biomechanical results compared with SIO, with fewer changes to the pelvic ring and the hip joints.

Key Words: Pelvic biomechanics, Pemberton pericapsular osteotomy, Salter innominate osteotomy

Introduction

Pelvic biomechanics is an important consideration when deciding on a surgical treatment strategy for developmental dysplasia of the hip (DDH). Salter innominate osteotomy (SIO) and Pemberton pericapsular osteotomy (PPO) affect hip and pelvic biomechanics in different ways, and previous reports in the orthopedic literature have cited the various advantages and disadvantages of each method. Few studies have compared the pelvic biomechanics of these two osteotomy techniques.

In this study, the pelvic biomechanics were compared for a series of patients who underwent SIO for one hip and PPO for the other hip, with correct indications.

Materials and Methods

Fifty-seven out of 126 patients who had undergone a one-stage procedure involving SIO for one hip and PPO for the other hip between 1993 and 2010 were able to be contacted and agreed to be included in this case series. All surgeries were performed with correct indications by one surgeon in our clinic.

Preoperative x-rays, archived reports and patient recall were obtained and retrospectively analyzed for these 57 patients. Intraoperative records were confirmed for each case. At the last clinical examination, postoperative x-rays and computerized tomography examinations were performed on patients to assess hip and pelvic biomechanics.

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Results

Lower limb discrepancy poses a potential risk to pelvic biomechanics in patients. We observed equal limb length in 4 patients, a mean 0.66-cm difference in hips treated with PPO (3 patients) and a mean 0.49-cm difference in hips treated with SIO (50 patients). SIO caused an average 0.47-cm lower limb discrepancy.

A positive Trendelenburg test result, which may be assumed to reflect unstable pelvic biomechanics, was found in 5 patients at the last clinical examinations (1 bilateral, 3 hips treated with PPO and 1 hip treated with SIO).

Based on x-rays, 3 hips treated with SIO and 1 hip treated with PPO had changes that may reflect unstable pelvic biomechanics. One hip treated with SIO had had postoperative complications, but for the remaining hips, the intraoperative technique appeared to have caused the instability.

Discussion

Hip Biomechanics Leading to Dysplasia and Hip Pain

The hip joint is a ball-and-socket joint, and its biomechanics were extensively described by Pauwels in 1976 [1, 2]. His work showed that to withstand a load, the length of the lever arm of the body weight (which extends from the body's center of gravity to the center of the femoral head) needs to be almost three times that of the abductor muscle lever arm [3].

The development of the femur and acetabulum is related to the directions and power of loads placed upon them. A change in these forces greatly affects the biomechanics between the femoral head and the acetabulum. In the displaced hip, movement of the femoral head from its center to its new position around a fixed axis.

A lack of contact with the posterior osteotomy line causes a mechanical load to the graft. The graft becomes unstable, and the acetabulum continues to move distally [11, 12]. Corrections of 22° (8°-34°) on the anteversion angle and 9.5° (2°-18°) on the inclination angle can be obtained. According to Salter, instability may also arise secondary to formation of a hernia pouch of the capsule. In these situations, capsulorrhaphy is also necessary. Tachdjian states that plication with excision of the extracapsular region and capsular repair using stretched sutures is the best way to obtain stability [16-18].

As a result, SIO gradually re-orientates the hip joint center to migrate distally, posteriorly and medially, and the acetabulum extends between the osteotomy lines, limiting the adduction of the acetabulum. After osteotomy, there is increased tightness of the hip flexors and adductors [12]. SIO increases the percentage of femoral head covered by the acetabulum, preventing advanced subluxation of the femoral head and subsequent arthrosis [4] and also permitting the cartilage to develop normally [19].
Biomechanical Features of Pemberton Pericapsular Osteotomy

PPO is an incomplete osteotomy. Its creator, Pemberton, emphasizes acetabular shallowness and insufficiency in the antero-superior acetabular regions as the primary problems. He also states that the triradiate (Y) cartilage can be used as hinge to modify the acetabular shape and volume and that sufficient anterolateral femoral head coverage can be obtained by using the iliopubic and ilioischial ramus as a hinge [20]. Pemberton proposed that this technique was suitable for children with dislocated or subluxated hips prior to early adolescence when the flexibility of Y cartilage is lost, i.e., from 1 until 12 years of age for girls and up to 14 years for boys. The success of the operation is closely related to the flexibility of the Y cartilage and the subsequent acetabular remodeling. This hinge effect provides more correction to the acetabular index by reducing the angle and generating less rotation, making the pelvis physiologically more stable. As there is no change to the inside volume of the pelvis, there is no risk of narrowing the birth canal. However, PPO can change the acetabular configuration and capacity and can cause a loss of adaptation between the femoral head and the acetabulum in later life.

The biggest concern with SIO is the difficulty in obtaining a stable position for fragments demonstrating sacrospinous rigidity. As PPO causes no changes to the posterior wall, sacrospinous changes are also minimal [21]. For this reason, PPO is a good choice for patients with sacrospinous rigidity.

Because PPO is an incomplete osteotomy, the pelvic ring is unchanged and the pelvic volume and therefore the birth canal do not change [21, 22]. Neither the use of K-wires nor their subsequent extraction is required [20], and the risk to the sciatic nerve and superior vasculature is low [21]. Pemberton reports 94.3% success with this technique [23].

In conclusion, SIO replaces the hip joint center distally, posteriorly and medially.Adduction of the acetabulum becomes restricted, and the abductor and flexor group muscles become more flexible. PPO, in contrast, is an incomplete osteotomy and does not alter the pelvic ring or size of the birth canal. The graft is placed tightly in line with the osteotomy, and stabilization with K-wires is not required. According to the findings in this study, PPO affects the biomechanics of the pelvis much less than does SIO. Overall, PPO demonstrated better biomechanical results than SIO with fewer changes to the pelvic ring and hip joints.

Conflict of interest statement: The authors declare that they have no conflict of interest to the publication of this article.

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