Treatment of Tönnis type II hip dysplasia with or without open reduction in children older than 18 months: a preliminary report

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Abstract

Purpose In this study, we aim to investigate whether the hip with Tönnis type II dysplasia in children older than 18 months can be treated without open reduction.

Methods In our study, 47 hips (47 patients) with type II developmental dysplasia of the hip according to the Tönnis classification were treated by a combination of open reduction through an anterolateral approach with iliopsoas tenotomy followed by innominate osteotomy and capsulorrhaphy or iliopsoas tenotomy followed by innominate osteotomy. The patients with open reduction constitute the open Salter group (32 hips), while the rest of the patients with innominate osteotomy alone constitute the closed Salter group (15 hips). The acetabular index (AI) and Smith's c–b and h–b index were assessed on the preoperative, immediate postoperative and final follow-up hip X-rays.

Results There were no statistically significant differences related to sex distribution, age and postoperative follow-up

time between the patients of each group. There was also no statistically significant difference between the preoperative AI of the open and closed Salter osteotomy groups. Overall, 80% of hips with open reduction had Smith's c–b ratio greater than the value of 1 and h–b ratio lower than the value of 0.05.

Conclusion The preoperative c–b index of the open osteotomy group was statistically greater than the c–b index of the closed osteotomy group and the preoperative h–b index of the open Salter group was statistically smaller than the h–b index of the closed Salter group, which means that most of the hips in the open osteotomy group are more in a lateralised and superior position compared to the closed osteotomy group. To us, there exists a subgroup of hips with less lateralisation and superior displacement according to the Smith's c–b and h–b ratio in Tönnis type II hip dysplasia. These hips might be less amenable to capsulorrhaphy because of the lower capsular instability and treatment may be done with closed reduction after iliopsoas tenotomy with Salter osteotomy in this select group of patients.

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Keywords Tönnis type II · Hip dysplasia ·
Closed reduction · Salter osteotomy

Abbreviations

AI Acetabular index
AVN Avascular necrosis

Introduction

The early diagnosis and treatment of developmental hip dysplasia is important because, as long as the hip remains

dislocated and the child becomes older, secondary changes around the hip make closed or open reduction more difficult.

The patients over 18 months of age with developmental hip dysplasia usually require additional procedures which will address these secondary changes in the proximal femur and acetabulum and the current treatment approach consists of primary open reduction with either a medial or an anterolateral approach, capsulorrhaphy and simultaneous acetabuloplasty [1–3].

In this study, we aimed to present our treatment strategy for the hips with Tönnis type II hip dysplasia in children older than 18 months and tried to find out whether open reduction was really needed.

Patients and methods

Between 1997 and 2006, 47 hips (47 patients) with type II developmental dysplasia of the hip according to the Tönnis classification were treated by a combination of open reduction through an anterolateral approach with iliopsoas tenotomy followed by innominate osteotomy and capsulorrhaphy or iliopsoas tenotomy followed by innominate osteotomy (Figs. 1–4). All of the operations were performed by the senior author (AE). The patients with open reduction constitute the open Salter group (32 hips), while the rest of the patients with innominate osteotomy alone constitute the closed Salter group (15 hips). Four of the 32 patients in the open innominate group and two of the 15 patients in the closed innominate group were male. Teratological, paralytic and pathological dislocations were excluded from the study group. At the time of operation, the mean age of the patients was 20.06 months in the open Salter group, while it was 22.4 months in the closed Salter

group. No patient had preliminary traction or previous treatment.

The acetabular index (AI), femoral neck shaft angles and Smith's c–b and h–b index were assessed on the pre-operative, immediate postoperative and final follow-up hip X-rays. Distance b was measured from the centreline c drawn vertically through the centre of the sacrum to Perkin's line.

Distance c, the amount of lateral displacement, was measured from the centre line to the most medial portion of the proximal femoral metaphysis (the beak).

If c exceeded b, the fraction would be greater than 1.0, indicating that the hip was dislocated. The amount of superior displacement was measured from the most displaced superior portion of the proximal metaphysis of the femur to Hilgenreiner's line, in which case the value would

Fig. 2 AP roentgenography of the child's left hip after closed Salter osteotomy

Fig. 1 Anteroposterior (AP) roentgenography of a 22-month-old child's left hip with Tönnis type II left hip dysplasia

Fig. 3 AP roentgenography of the child's left hip 9 years after closed Salter osteotomy

Fig. 4 Frog-leg roentgenography of the child's left hip 9 years after closed Salter osteotomy

be negative. The ratio $c-b$ gave the lateral displacement and $h-b$ gave the superior displacement [4–6].

The classification of hip dysplasia was made according to the Tönnis classification. In patients with Tönnis type I hip dysplasia, the femoral head's ossification centre is medial to Perkin's line. In Tönnis type II hip dysplasia, the femoral head's ossification centre is lateral to Perkin's line and below the transverse line passing from the superolateral rim of the acetabulum. In Tönnis type III hip dysplasia, the femoral head's ossification centre is at the level of the transverse line passing from the superolateral rim of the acetabulum and in Tönnis type IV hip dysplasia, the femoral head's ossification centre is above the level of the transverse line passing from the superolateral rim of the acetabulum. These patients were included in the study. Classification of avascular necrosis (AVN) was made according to the Kalamchi classification [7].

Surgical technique

The patients were operated in the supine position with a sandbag under the ipsilateral hip. An anterolateral approach was used. The straight head of the rectus femoris was elevated from the anterior inferior iliac spine and the reflected head transected. The iliopsoas tendon was divided at the pelvic brim. The stability of the hip was assessed in 20° abduction and flexion following the iliopsoas tenotomy, and it was considered to be stable when there were no signs of instability associated with the capsular laxity. As a second measurement for stability, the appearance of the ossific nucleus of the femoral head was checked with the image intensifier for whether it was opposite to the triradiate cartilage and medial to Perkin's line.

When open reduction was necessary, the capsule was opened by an incision parallel to the edge of the

acetabulum and an inverted U flap raised from the femoral side. The ligamentum teres and the transverse acetabular ligament were excised. The iliac wing was exposed subperiosteally and two Hohmann retractors were placed in the sciatic notch. The osteotomy started approximately 15 mm above the acetabulum between the anterior superior and the anterior inferior iliac spines, and run obliquely into the sciatic notch. It was performed with an osteotome under direct vision and the osteotomy line was parallel to the acetabular surface on the anteroposterior (AP) view. The superior articular margin of the acetabulum was followed in order to determine the angle of the osteotomy. Secondary to the oblique direction of the osteotomy, the distal part of the ilium lay parallel to the floor when the osteotomy line was opened by using towel clips on both sides, but not pulling proximally on the proximal fragment. Professor Salter stressed the importance of not pulling proximally on the proximal fragment because this manipulation can cause the proximal ilium to rotate through the sacroiliac joint rather than displaying the distal fragment so that the acetabular dysplasia may not be corrected, even though osteotomy appears to be opening appropriately. A triangular graft was taken from the ipsilateral iliac wing, with sides approximately 15 × 25 mm long, and was placed into the osteotomy perpendicular to the weight-bearing axis. The stability was tested in the mediolateral direction and by a push–pull test, pushing the ipsilateral hip upwards. Pins were inserted if the surgeon was not satisfied with the stability of the graft; otherwise, no internal fixation is used. In patients who had required open reduction, the hip was relocated; the U flap is inverted and sutured to the anteromedial acetabulum and excess capsule excised. Patients were put into a hip spica for 6–8 weeks and the wound not inspected unless clinically indicated. An abduction orthosis was then used for 3 months [8, 9].

Statistical analysis

NCSS 2007 software was used for the statistical analysis. Besides the descriptive statistical analysis methods (mean value, standard deviation), we used analysis of variance (ANOVA) to test for repeated measures, the Newman–Keuls test for multiple comparisons, paired *t*-tests before and after treatment, unpaired *t*-tests for comparing two groups and the Chi-square test for qualitative data evaluation. The results were evaluated for the significance level <0.05 .

Results

There were no statistically significant differences related to sex distribution, age and postoperative follow-up time

between the patients of each group. There was also no statistically significant difference between the preoperative AI of the open and closed innominate osteotomy groups (Table 1).

Comparing the preoperative AI of the open innominate group to the early postoperative and late (at the last visit) AI of the same group, there was a statistically significant difference (Table 2).

The preoperative AI of the open osteotomy group was statistically greater than the early AI of the open osteotomy group and, similarly, the early AI of the open innominate osteotomy group was statistically greater than the late AI of the same group. There was a statistically significant difference between the preoperative AI of the closed innominate osteotomy group compared to the early and late AI of the same group (Table 3). The preoperative AI of the closed osteotomy group and the early AI of the closed innominate osteotomy group were statistically greater than the early and late AI of the same group, respectively. There was no statistically significant difference related with the correction of the AI between the closed and open innominate osteotomy groups (Table 4).

The preoperative c–b index of the open osteotomy group was statistically greater than the c–b index of the closed osteotomy group, which means that the femoral head the open osteotomy group was in a more lateral position compared to the closed innominate group.

The preoperative h–b index of the open innominate group was statistically smaller than the h–b index of the closed innominate osteotomy group, which means that the femoral head in the open innominate group was in a more superior position compared to the closed innominate group (Table 5).

There were no statistically significant differences between the postoperative c–b and h–b indexes of both groups. There were two type III, three type II and one type I AVN in the open innominate osteotomy group. Although

Table 1 No statistically significant difference was found between the preoperative acetabular index (AI) of the open and closed innominate osteotomy groups

	Open Salter group (<i>n</i> = 32)	Closed Salter group (<i>n</i> = 15)	<i>P</i> -value
Operation age (months)	20.06 ± 2.97	22.4 ± 6.1	0.082
Sex distribution			
Male (%)	4 (12.5)	2 (13.3)	
Female (%)	28 (87.5)	13 (86.7)	0.936
Postoperative follow-up (months)	42.56 ± 14.49	48.8 ± 23.22	0.265
Preoperative AI	41.5 ± 6.76	38.8 ± 5	0.176

Table 2 Comparison of the preoperative AI of the open innominate group to the early postoperative and late AI of the same group

Newman–Keuls multiple comparison test	<i>P</i> -value
Preoperative AI/early AI	0.001
Preoperative AI/late AI	0.001
Early AI/late AI	0.001

Table 3 Comparison of the preoperative AI of the closed innominate osteotomy group to the early postoperative and late AI of the same group

Newman–Keuls multiple comparison test	<i>P</i> -value
Preoperative AI/early AI	0.001
Preoperative AI/late AI	0.001
Early AI/late AI	0.001

Table 4 There was no statistically significant difference related with the correction of the AI between the closed and open innominate osteotomy groups

	Open Salter group (<i>n</i> = 32)	Closed Salter group (<i>n</i> = 15)	<i>P</i> -value
AI correction	9.19 ± 5.66	8.67 ± 3.54	0.745

Table 5 The preoperative h–b index of the open innominate group was statistically smaller than the h–b index of the closed innominate group

	Open Salter group (<i>n</i> = 32)	Closed Salter group (<i>n</i> = 15)	<i>P</i> -value
c–b			
Before treatment	1.07 ± 0.09	0.94 ± 0.06	0.0001
After treatment	0.72 ± 0.05	0.69 ± 0.07	0.121
h–b			
Before treatment	0.04 ± 0.04	0.15 ± 0.21	0.004
After treatment	0.18 ± 0.04	0.17 ± 0.04	0.742

Table 6 No avascular necrosis (AVN) had been detected in the closed innominate osteotomy group

	Open Salter group (<i>n</i> = 32) (%)	Closed Salter group (<i>n</i> = 15) (%)	<i>P</i> -value
AVN (–)	27 (84.4)	15 (100)	0.105
AVN (+)	5 (15.6)	0 (0)	

there were no statistically significant differences related with AVN among each group, no AVN had been detected in the closed innominate osteotomy group (Table 6).

Discussion

After years of follow-up of patients with developmental hip dysplasia, the senior author noticed that, in some children with type II dysplasia according to the Tönnis classification, the iliopsoas tenotomy was not sufficient enough to gain the necessary capsular laxity to perform a perfect capsulorrhaphy. Thus, he started to make closed innominate osteotomy in this select group of patients. In our study, the open or closed reduction decision was made based on the intraoperative findings. In our series, we did not perform a preoperative selection of patients for capsulorrhaphy.

The pathological changes occurring in a dysplastic hip in a newborn are generally reversible, but late diagnose causes more prominent secondary changes, which are also difficult to overcome. The current treatment approach for children older than 18 months with dysplasia of the hip is primary open reduction through a medial or anterolateral approach and acetabuloplasty. We had preferred the anterolateral approach in our cases because of the high rates of secondary interventions and ensuing AVN after open reduction through a medial approach in this age group [10].

The stability of the hip was assessed in 20° abduction and 20° flexion following the iliopsoas tenotomy and it was considered to be stable when there were no signs of instability associated with the capsular laxity. As a second measurement for stability, the appearance of the ossific nucleus of the femoral head was checked with the image intensifier whether it was opposite to the triradiate cartilage and medial to Perkin's line, but we could have used arthrography in addition to this.

According to the Salter and Dubos [11], in the operative treatment for hip dysplasia, AVN was a complication of open reduction rather than osteotomy itself. We think that this might be the reason for increased predilection for AVN risk in the open osteotomy group compared to the closed osteotomy group in our cases. But follow-up period of the patients is not adequate to draw stronger conclusions, and further follow-up is mandatory in order to draw more definite conclusions.

Smith's h–b and c–b ratios are both reliable for detecting the superior and lateral displacement of the femoral head, respectively [12]. Patients in whom we have achieved closed reduction had preoperative Smith's c–b ratio never above the value of 1, and in 28 of 35 patients in whom we had to perform open reduction had c–b ratio above the value of 1. In patients in whom we have achieved closed reduction, Smith's h–b ratios were all above the value of 0.05, and in 26 of 35 patients in whom we had to perform open reduction had h–b ratio lower than the value of 0.05. So, most of the patients with preoperative Smith's c–b ratio lower than 1 and/or h–b ratio above 0.05 were able to be treated with closed reduction. Overall, 80% of

hips with open reduction had Smith's c–b ratio above the value of 1 and h–b ratio lower than the value of 0.05.

To us, the subgroup of hips with less lateralisation and/or superior displacement according to the Smith's c–b and h–b ratios in Tönnis type II hip dysplasia might be less amenable to capsulorrhaphy because of the lower capsular instability and treatment may be done with closed reduction after iliopsoas tenotomy with innominate osteotomy in this group of patients.

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Conflicts of interest statement The authors declare that they have no competing interests.

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