

Long-Term Survivorship of Hip Shelf Arthroplasty and Chiari Osteotomy in Adults

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Abstract: The current authors retrospectively assessed 56 hip shelf arthroplasties (48 patients) with a mean followup of 17 years (range, 15–30 years) and 89 Chiari osteotomies (82 patients) with a mean followup of 13 years (range, 6–25 years) done in adults with painful hip dysplasia. Preoperative joint space narrowing was observed in 32 of 56 shelf arthroplasties and in 67 of 89 Chiari osteotomies. Survival rates, using hip replacement as the end point, were 37% (20% to 54%) at 20 years for shelf arthroplasty and 68% (54% to 81%) at 18 years for Chiari osteotomy. The severity of preoperative arthrosis was the main factor that impaired the survivorship of shelf arthroplasty and Chiari osteotomy. With arthritic changes without joint space narrowing, the 18-year survival rates were 83% (69% to 97%) for shelf arthroplasty and 94% (89% to 99%) for Chiari osteotomy. Shelf arthroplasty is best indicated for moderate dysplasia (center edge angle $>0^\circ$) without severe arthrosis. Chiari osteotomy is best suited for severe dysplasia (center edge angle $<0^\circ$) especially without or with slight arthrosis. Chiari osteotomy also can be a salvage procedure when marked joint space narrowing is present but only if it is related to severe dysplasia (center edge angle $<0^\circ$).

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INTRODUCTION

Despite consistent technical progress, the behavior of a THR done for dysplastic arthrosis in young adults remains uncertain.^{4,5,24} For young adults, the rate of revision THR or impending failure ranges from 15% to 65.4% in long-term studies.^{5,16,19,23,25} Young active adults suffering from this disease are highly exposed to premature wear, which mainly is related to activity level.²¹ Despite the high risk of reoperation, many patients prefer the quick recovery of a THR instead of the long-term result usually obtained after a conservative procedure. In fact, the period of rehabilitation is longer after conservative procedures around the hip, particularly if a proximal femoral

osteotomy is done.² Consequently, to convince patients to have such procedures, one needs accurate indications, particularly to avoid the early failures that are unacceptable to young patients. The goal of the current study was to define, on the basis of a long-term assessment (>10 years), the adequate indications for hip shelf arthroplasty and Chiari pelvic osteotomy in acetabular dysplasia in adults.

MATERIALS AND METHODS

Hip Shelf Arthroplasty

Sixty-five shelf arthroplasties were done between 1964 and 1977 in 57 patients with a mean age of 32 ± 14 years (range, 17–56 years). Only two patients were older than 50 years. Nine hips were excluded from functional assessment but were included in survivorship analysis: two patients died, five patients were lost to followup, and two patients had early revision by a Girdlestone procedure because of severe infections. Consequently, the functional results were evaluated in 56 hips (48 patients). Before surgery, all the hips had a dysplastic acetabulum: all the center edge angles were less than 20° (mean, $4.5 \pm 9^\circ$ [range, -32° to 19°]), and all the center anterior edge angles of Lequesne were less than 20° (mean, $5.3 \pm 10^\circ$ [range, -16° to 18°]).¹¹ There were 39 developmental dysplasias and 17 late evolutions of congenital hip dislocation for which the patients were treated during childhood (Fig 1). Eighteen of the 56 shelf arthroplasties (15 patients) had a severe hip dysplasia defined by a preoperative center edge angle less than 0° . Arthrosis was assessed according to De Mourgues and Patte¹⁴: Grade 1, no signs of arthrosis; Grade 2, bone cyst or sclerosis without joint space narrowing; Grade 3, less than 50% joint space narrowing; and Grade 4, more than 50% joint space narrowing. Before shelf arthroplasty, all the hips had some degree of arthrosis that was severe (Grade 3 [18 hips] and Grade 4 [14 hips]) in 32 hips (57%) (28 patients), and slight (Grade 2) in 24 hips (20 patients) (Fig 1). Fourteen hips had a joint space thickness of 1 mm or less, 18 hips had a joint space thickness of 2 or 3 mm, and 24 hips had a joint space thickness of 4 mm or more. Hip subluxation was diagnosed when breakage of the Shenton line greater than 5 mm was seen on the AP view: 26 hips had a subluxation before surgery. Hip congruency was assessed according to three grades on the AP

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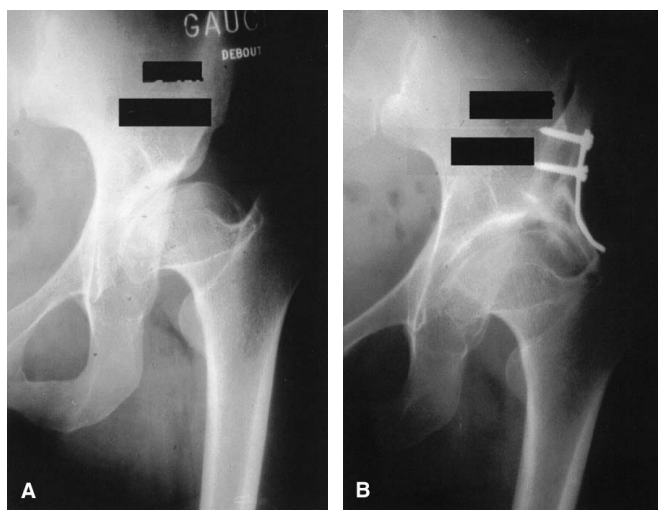


FIGURE 1. A, Preoperative AP radiograph of a 24-year-old woman shows a slight dysplasia (center edge angle, 4°), no loss of congruency but a loss of the femoral head sphericity, and an acetabular roof condensation without joint space narrowing (arthrosis Grade 2). The patient had a congenital hip dislocation for which she was treated conservatively during childhood. B, Anteroposterior radiograph taken 20 years after shelf arthroplasty shows no evidence of arthrosis progression; the bone density of the graft was satisfactory. The Merle d'Aubigné hip rating increased from 15 points preoperative to 18 points at the last followup.

view: normal congruency (16 hips), a slight loss of congruency when 3 mm or less was measured between the largest and the narrowest areas of joint space (27 hips), and severe loss of congruency when more than 3 mm was measured between the same landmarks (13 hips). Shelf arthroplasties were done through a Smith-Petersen approach. An autologous bone block was harvested from the anterior iliac crest and impacted in a groove prepared above the acetabulum. The bone block was positioned tangent to the femoral head, close to the hip capsule, and orientated according to radiographic data to correct the deficient acetabulum (usually at the anterolateral aspect). A small screwed plate (Fig 1) maintained the graft.

Chiari Pelvic Osteotomy

Ninety-nine Chiari pelvic osteotomies were done from 1975 to 1992 in 92 patients with a mean age of 33.9 ± 11 years (range, 17–56 years). Only three patients were older than 50 years. Ten hips were excluded from functional assessment but enrolled for survival analysis: three patients died and seven patients were lost to followup. Consequently, the functional results were assessed in 89 hips (82 patients). There were 50 developmental dysplasias and 39 hips were late evolutions of congenital hip dislocation for which the patients were treated during childhood (30 treated conservatively and nine surgically reduced). Before surgery, all the hips had an acetabular

dysplasia: all the center edge angles were less than 20° (mean, $0.7^\circ \pm 9$ [range, -22 to 19°]), and all center anterior edge angles of Lequesne were less than 20° (mean, $-3.2^\circ \pm 11^\circ$ [range, -42° to 19°]). Thirty-one of the 89 Chiari pelvic osteotomies had a severe hip dysplasia with preoperative center edge angles less than 0° (Fig 2). Arthrosis was assessed according to the

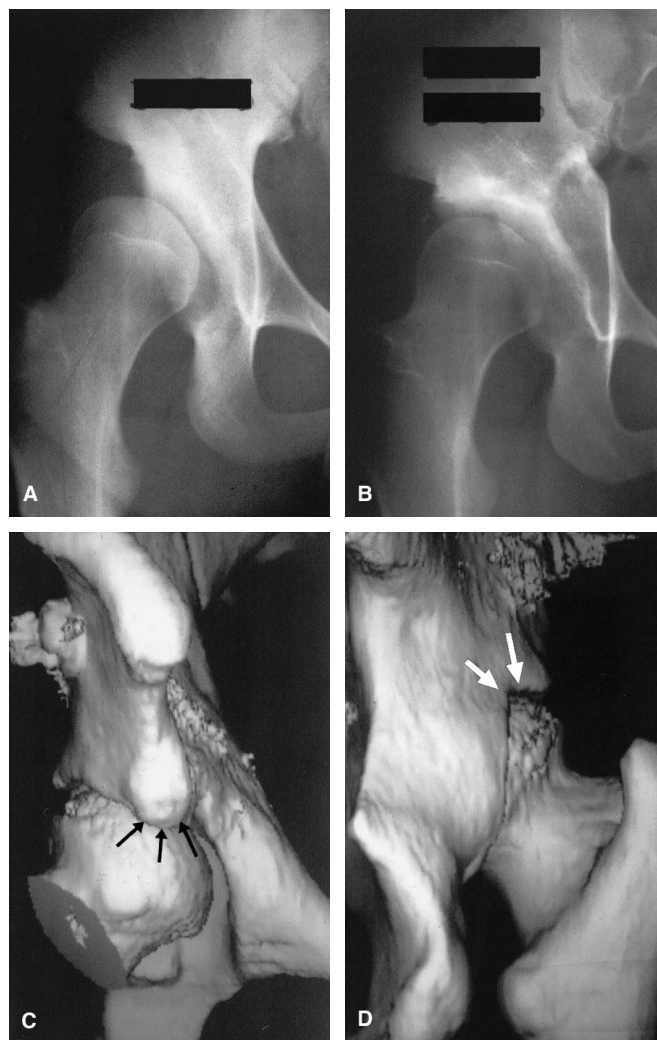


FIGURE 2. A, Preoperative AP radiograph of a 25-year-old man shows severe developmental hip dysplasia. The center edge angle was -15° . The patient had a severe hip subluxation, a slight loss of congruency, and slight arthrosis (Grade 2) limited to a severe acetabular bone condensation. B, Anteroposterior radiograph taken 15 years after Chiari pelvic osteotomy (the screw was removed for the CT scan). The patient's hip rating increased from 14 points preoperative to 18 points at the last followup. The femoral head coverage was complete without progression of arthrosis or subluxation. C, Anterior and (D) posterior three-dimensional CT scan reconstructions taken at 15 years of followup can be seen. The design of the Chiari osteotomy (dome-shaped) allowed excellent coverage of the anterior and posterior aspects of the femoral head (arrows).

criteria defined for shelf arthroplasty.¹⁴ Before Chiari pelvic osteotomy, all the hips had some degree of arthrosis that was severe (Grade 3 [47 hips] and Grade 4 [20 hips]) in 67 hips (75%) (64 patients) (Fig 3), and slight in 22 hips (Grade 2) (22 patients) (Fig 2). Twenty hips had a joint space thickness of 1 mm or less, 47 hips had a joint space thickness of 2 or 3 mm, and 22 hips had a joint space thickness of 4 mm or more. Hip subluxation was assessed with the same criteria as for shelf arthroplasty: 43 hips had a subluxation (Fig 3). According to the criteria defined for shelf arthroplasty, congruency was normal in 18 hips, had a slight loss in 52 hips, and had a severe loss in 18 hips.

The Chiari pelvic osteotomies were done through a Smith-Petersen approach with limited subperiosteal exposure. Some modifications differed from Chiari's original technique: (1) the osteotomy, orientated upward and inward, was guided by wires with an image intensifier; (2) the osteotomy was done by means of curved chisels with a dome shaped design (Fig 2) to be congruent with the femoral head^{1,18}; and (3) the acetabulum was displaced medially to obtain a full coverage of the femoral head, then fixed with a lag screw (Fig 3).

Methods of Assessment

All of the patients who were available (alive, not lost to followup) were reviewed retrospectively by two examiners

who did not participate in the surgery. Functional status was assessed according to the hip rating of Merle d'Aubigné.¹³ The last hip rating before reoperation was recorded when conversion to a THR was done. Anteroposterior views taken with the patient standing were obtained at followup. Preoperative and followup radiographs were assessed twice by two examiners. The statistical methods were simple regression analysis and ANOVA for continuous variables and chi square was used for discrete variables. When the samples were small, nonparametric tests were done (Wilcoxon, Kruskal-Wallis, Mann-Whitney). Differences were considered significant when the probability value was less than 0.05. All values were expressed as means \pm standard deviation. A survival analysis was done according to Kaplan-Meier using date of conversion to THR as the end point.⁷ The Log-rank test was used to compare survival rates. Confidence intervals at 95% are indicated to detail survival rates.

RESULTS

Hip Shelf Arthroplasty

At a mean followup of 17.1 ± 5 years, the Merle d'Aubigné functional score for 56 hips was: excellent in four hips (18 points), very good in seven hips (17 points), good in 10 hips (15 and 16 points), fair in 14 hips (13 and 14 points),

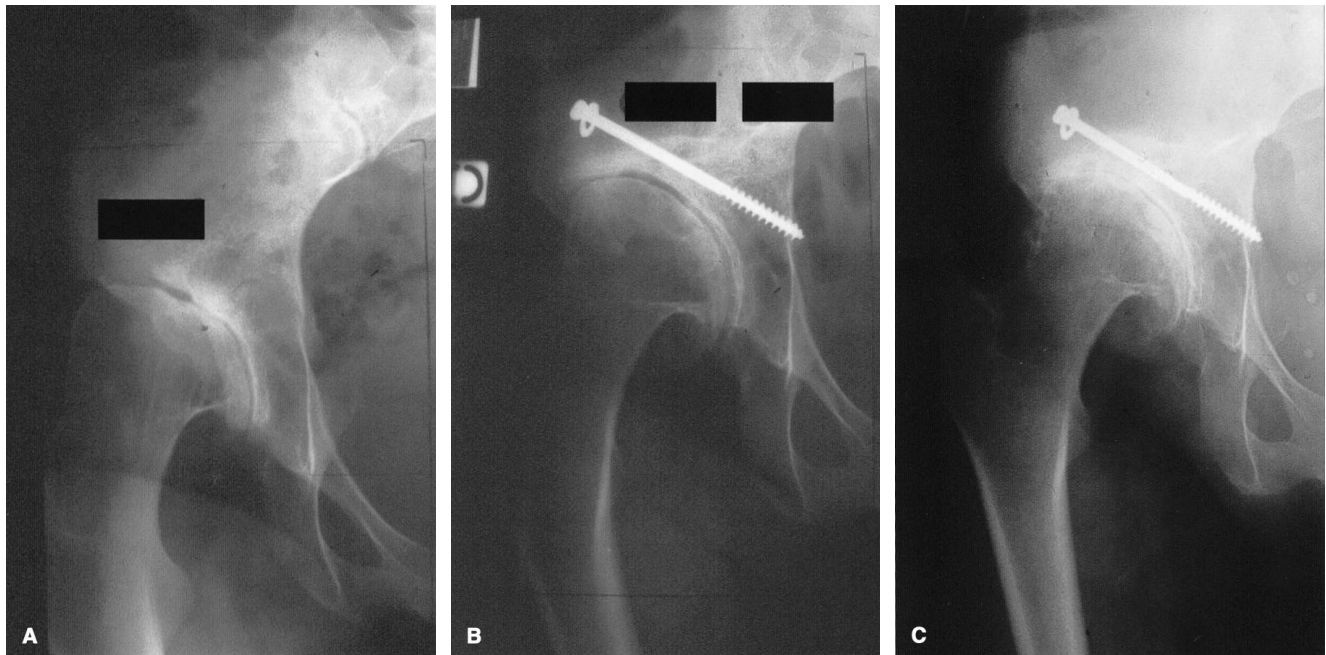


FIGURE 3. A, Preoperative AP radiograph shows a 35-year-old woman with a late evolution of congenital hip dislocation surgically reduced during childhood. Hip arthrosis was severe (Grade 4) with a joint space narrowing. The dysplasia also was severe, with a center edge angle of -10° . The patient had a severe subluxation and a deformity of the femoral head. B, Nine years after Chiari pelvic osteotomy, there was complete coverage of the femoral head and improvement of arthrosis. The functional hip rating increased from 11 points preoperative to 18 points at the last followup. C, Eighteen years after Chiari pelvic osteotomy, just before the conversion to a THR, there was an increase of arthrosis and the functional rating decreased to 14 points.

poor in 17 hips (9 to 12 points), and bad in four hips (<9 points). Radiographic features of arthrosis were stabilized in 33 hips, improved in five hips, and worsened in 18 hips. The functional result was not different when shelf arthroplasty was done for developmental dysplasia or late congenital hip dislocation.

At the latest followup, 25 shelf arthroplasties (23 patients) had been converted to a THR: 17 before 15 years (early failures) and eight after 15 years of followup (late failures). These 25 THRs were done without acetabular bone grafting. The survival rates established for the 65 hips were 58% (confidence interval, 42% to 74%) at 15 years and 37% at 20 years (confidence interval, 20% to 54%). Only 39 shelf arthroplasties (32 patients) still were functional after 15 years (mean followup, 20 ± 3 years [range, 16–30 years]), but 18 hips (46%) (17 patients) were pain-free or slightly painful (Fig 1). Among these 39 hips, the functional results were excellent in four hips, very good in seven hips, good in 10 hips, fair in 11 hips, poor in five hips, and bad in two hips. Arthrosis was the main reason for failure: the Kaplan-Meier survival rate at 18 years was 83% (confidence interval, 69% to 97%) when arthrosis was slight (Grade 2) and only 27% (confidence interval, 12% to 42%) when arthrosis was severe (Grades 3 and 4) ($p = 0.0001$). The adverse effect of arthrosis was promoted by a lack of congruency for early failures ($p = 0.005$), and by severity of acetabular dysplasia and hip subluxation for late failures ($p = 0.01$).

Chiari Pelvic Osteotomy

At a mean followup of 13.5 ± 4 years (range, 6–25 years), 62 hips (69%) (57 patients) were pain-free or had slight pain. According to Merle d'Aubigné, the functional results were excellent in 22 hips, very good in 21 hips, good in 17 hips, fair in 15 hips, poor in 11 hips, and bad in three hips. The greater the preoperative hip dysplasia (lower center edge angles) and the less arthrosis before surgery, the better the functional result at followup ($p = 0.0001$). Likewise, functional results were better with greater improvements in center edge angles ($p = 0.001$). The functional result was not different when Chiari osteotomy was done for a developmental dysplasia or a late congenital hip dislocation. Radiographic features of arthrosis were stabilized in 30 hips, slightly improved in 20 hips (Fig 3), and worsened in 39 hips.

At the latest followup, 23 Chiari osteotomies (22 patients) had been converted to THRs and were included as failures: 11 before 6 years followup and 12 at a mean of 13 years (range, 8–18 years). Only one of these 23 THRs needed an acetabular bone grafting to correctly locate the hip center as the Chiari osteotomy previously was done in a severe subluxation. All 11 conversions (11 patients) to a THR done before 6 years followup had before surgery a slight dysplasia (center edge angle $\geq 0^\circ$) combined with severe arthrosis (Grades 3 and 4). The 12 Chiari osteotomies (11 patients) that were converted

late to a THR had been done in older patients and in patients who had more severe arthrosis before surgery ($p < 0.001$). The survival rates established for 99 hips were 84% (confidence interval, 80% to 88%) and 68% (confidence interval, 54% to 81%) respectively at 10 and 18 years. At 18 years, the same probability was 94% (confidence interval, 89% to 99%) when arthrosis was slight (Grade 2), and 74% (confidence interval, 66% to 82%) and 54% (confidence interval, 34% to 74%) respectively when arthrosis was Grade 3 and Grade 4 ($p < 0.0001$). Only three conversions (9.6%) were done among the 31 hips (28 patients) that had negative preoperative center edge angles (20 hips (65%) had Grade 3 and Grade 4 preoperative arthrosis), compared with 20 conversions (29.4%) in the 58 hips (56 patients) that had a center edge angle greater or equal to 0° (47 hips (70%) had Grade 3 and Grade 4 preoperative arthrosis) ($p = 0.03$). Likewise, among the 67 hips (64 patients) with severe preoperative arthrosis (Grades 3 and 4), only two of the 21 hips (9%) with a center edge angle less than 0° were converted to a THR compared with 19 of the 46 hips (39%) that had center edge angles greater or equal to 0° ($p = 0.01$). Hip congruency or severity of subluxation had no influence on functional result or survival rate of Chiari osteotomy (Fig 2).

DISCUSSION

By comparison with reorientation procedures, the enlargement of the acetabulum could appear obsolete, because it does not bring hyaline cartilage over the femoral head.^{8,9,17} However, despite the high frequency of preoperative arthrosis in the current study, these procedures had a satisfactory survival rate: 37% at 20 years for shelf arthroplasty and 68% at 18 years for Chiari osteotomy. The majority of the procedures done to treat acetabular dysplasia are very sensitive to arthrosis.^{17,26} Trousdale et al²⁶ reported at a mean followup of 4 years, six conversions to THR of 42 Bernese osteotomies (14%) done for dysplastic osteoarthritic hips. Similarly, Nakamura et al¹⁷ reported only 27% of good clinical results after rotational osteotomies of the acetabulum at a mean followup of 13 years. The current study confirmed the survivorship of enlargement procedures also was sensitive to arthrosis, especially shelf arthroplasty, which had only 27% survivorship at 18 years when preoperative arthrosis was severe (Grades 3 and 4). These results suggest shelf arthroplasty should not be done when arthrosis is severe. The Chiari osteotomy was less sensitive to arthrosis, considering the 54% 18-year survival rate in patients with Grade 4 arthrosis. Moreover, when patients had Grade 3 or Grade 4 preoperative arthrosis, the rate of conversion to a THR was divided by 4 when the dysplasia was severe with a center edge angle less than 0° . Whatever the severity of arthrosis, the Chiari osteotomy had better results in patients with a severe hip dysplasia. The current authors recommend this procedure only when the center edge angle is less than 0° .

Without or with slight arthrosis these procedures gave satisfactory results with 83% survival rate at 18 years for shelf arthroplasty and 94% survival rate at 18 years for Chiari osteotomy. In this subgroup, when the dysplasia was severe (center edge angle $<0^\circ$), shelf arthroplasty had a higher rate of late failures than Chiari osteotomy, especially when the subluxation was severe and with a loss of congruency. Therefore, Chiari osteotomy would be recommended for these patients because the results were not influenced by these two hip deformities.

Some technical features must be followed to obtain a satisfactory result after a Chiari osteotomy: (1) the osteotomy must be congruent, as recommended by Nakata et al¹⁸ and Anwar et al¹; (2) a limited subperiosteal exposure of the gluteal fossa may help to avoid postoperative limp; (3) contrary to Fernandez et al³ intraoperative hip traction should not be applied to avoid intraarticular osteotomy, which could lead to osteonecrosis and poor results²⁰; (4) full coverage of the femoral head should be obtained and, to facilitate mobilization of the acetabulum, the osteotomy must be orientated upward and inward.^{6,11,12} The practice of a congruent osteotomy probably is the most valuable point because it permits extensive coverage of the femoral head (Fig 2), which frequently is incomplete when a flat osteotomy is done.⁸

Based on the long-term results (>10 years) and a low rate of patients lost to followup (7.6% for shelf arthroplasty, 7% for Chiari osteotomy) reported in the current study, current indications for the two procedures could be recommended: (1) shelf arthroplasty should be indicated for patients with a slight dysplasia (center edge angle $\geq 0^\circ$), especially those without arthrosis and if possible patients without loss of joint congruency and hip subluxation; and (2) Chiari osteotomy only should be done in patients with a severe hip dysplasia (center edge angle $<0^\circ$), whatever loss of congruency and subluxation (subluxation does not contraindicate Chiari osteotomy until the osteotomy could be ascendant and ends below the sacroiliac joint) (Fig 3). Chiari osteotomy is best suited when arthrosis is slight, but severe joint space narrowing does not contraindicate it unless the dysplasia is slight (center edge angle $\geq 0^\circ$) (Fig 3). These augmentation procedures can be done for either developmental dysplasia or late evolution of congenital hip dislocation.

The rate of conversion to a THR was significantly higher for the patients with shelf arthroplasties (25 of 56 [44.6%]) compared with patients with Chiari osteotomies (23 of 89 [25.8%]), despite a higher incidence of severe preoperative arthrosis (Grades 3 and 4) in the Chiari group. This confirms the higher sensitivity of shelf arthroplasty to arthrosis and prompted the current authors to recommend Chiari osteotomy in such a circumstance, especially if associated with a severe dysplasia. The conversion rates are high, but augmentation procedures made the cup implantation simple without the need for acetabular augmentation bone grafting, except in one pa-

tient, to correct the high hip center of a previously dislocated hip.

As advocated by Klaue et al,⁸ these augmentation procedures can be proposed as a salvage surgery when the acetabular reorientation is not possible (severe subluxation or incongruency). However, when the dysplasia is extremely severe (center edge angles $<-15^\circ$), the acetabular reorientation can give adverse effects: (1) reduction of the coverage of the posterolateral quadrant of the femoral head sometimes required to obtain full correction, as reported by de Kleuver et al.⁹ These authors pointed out this phenomenon could impair the functional score and reduce the survival of reorientation procedures of the acetabulum; (2) an incomplete correction of severe acetabular dysplasia, observed after spherical osteotomies in 8.8% by Schramm et al²²; and (3) an anterior femoroacetabular impingement induced by excessive displacement of the acetabulum needed to correct dysplasia.¹⁵ The Chiari osteotomy should be an adequate procedure in such a situation (center edge angle $<-15^\circ$) because it showed in the current study a regular ability to correct extremely severe acetabular dysplasias without adverse effects. However, technical details should be followed to achieve a significant hip medialization required to obtain complete and congruent coverage of the femoral head.

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