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# The Chiari pelvic osteotomy for patients with dysplastic hips and poor joint congruency : LONG-TERM FOLLOW-UP

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■ HIP

# The Chiari pelvic osteotomy for patients with dysplastic hips and poor joint congruency

## LONG-TERM FOLLOW-UP

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**We report the mid- to long-term (mean 20.3 years, 10 to 32.5) results of the Chiari pelvic osteotomy in patients with pre- to advanced stage osteoarthritis in dysplastic hips. We followed 163 Japanese patients (173 hips) with a mean age at surgery of 20 years (9 to 54). Overall, 124 hips (72%) had satisfactory results, with Harris hip scores ≥ 80. Satisfactory results were seen in 105 of 134 hips with pre- or early osteoarthritis (78%) and 19 of 39 hips with advanced osteoarthritis (49%). A total of 15 hips (9%) underwent a total hip replacement (THR) with a mean interval between osteotomy and THR of 16.4 years. With conversion to THR as the endpoint, the 30-year survival rate was 85.9% (95% confidence interval 82.3 to 89.5). It was 91.8% for patients with pre- or early osteoarthritis and 43.6% for those with advanced osteoarthritis ($p < 0.001$).**

**We now perform the Chiari osteotomy for patients with dysplastic hips showing poor joint congruency and who prefer a joint-conserving procedure to THR.**

Patients with acetabular dysplasia generally develop secondary osteoarthritis (OA).[1] In 1955 Chiari[2] described a medial displacement pelvic osteotomy for the treatment of congenital subluxation and reported good results after five years.[3] Despite his commitment to the osteotomy in younger children, it is generally agreed that it gives the best results in adolescents and young adults.[4-6] It has been of value in the management of symptomatic incongruent dysplasia of the hip when realignment osteotomy has not been effective.[6] Good mid- to long-term clinical results are reported in 37% to 92% of hips.[4-9]

Since 1973, we have performed a Chiari pelvic osteotomy in patients with acetabular dysplasia using a transtrochanteric approach. The radiological appearances and mid-term outcomes were reported in 2003 and 2004.[10,11] We asked whether the osteotomy still had a role in the treatment of patients with symptomatic acetabular dysplasia and present the outcome at a mean follow-up of 20.3 years (10 to 32.5).

## Patients and Methods

Our treatment principle for patients with OA of the hip secondary to congenital dislocation, subluxation or dysplasia has been to provide good bony femoral head cover by reconstructive osteotomies of the pelvis. A rotational periacetabular osteotomy or shelf procedure was used in adults who had a spherical femoral head, an intact joint space and good congruity between the acetabulum and the femoral head. A Chiari osteotomy was used in patients with an irregular femoral head or incongruity between the acetabulum and femoral head, with arthritis, as graded from 0 to 3 by Tönnis.[12] We did not undertake osteotomy for patients with complete obliteration of the joint space. Preoperatively, all patients had dysplasia of the hip and complained of moderate to severe pain.

Between 1973 and 2000, a total of 239 Chiari osteotomies were performed in 231 consecutive patients. Five patients have subsequently died. We were unable to trace 57 patients as a result of refusal to participate, deterioration of health precluding return for assessment, or loss to follow-up. We were able to follow-up 169 patients (173 hips, 74%, 165 unilateral, four bilateral) for more than ten years. Their mean age at operation was 29 years (9 to 54, Fig. 1); 24 were male and 145 were female; 96 left hips were treated and 77 right hips. The mean follow-up was 20.3 years (10 to 32.5).

Patients were classified into two groups; the first group (131 patients, 134 hips) included those with pre- or early-stage OA (Tönnis grade 0 to 2) and the second (38 patients, 39 hips) included those with advanced OA (Tönnis 3).[12]

The operative techniques have been described previously.[10,11] An anterior iliofemoral approach

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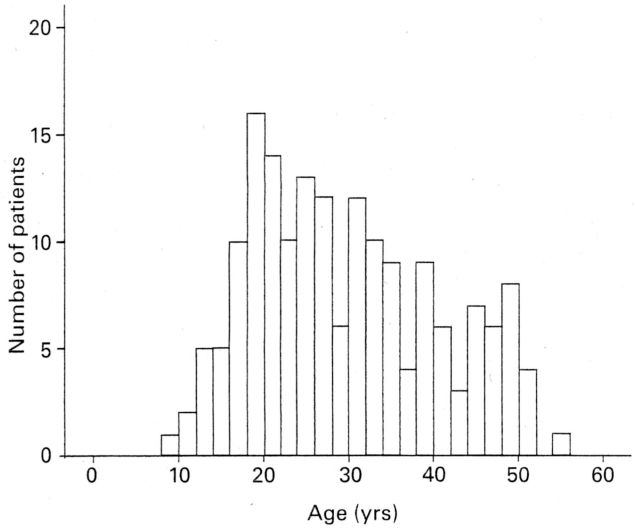


Fig. 1

Histogram showing the number of patients according to age at the time of Chiari osteotomy.

Fig. 2a

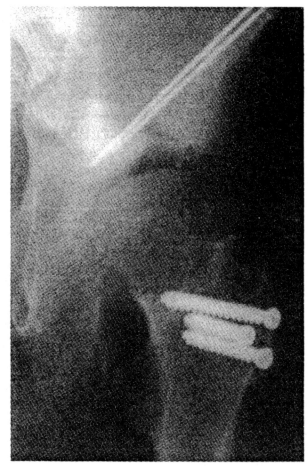

Fig. 2b

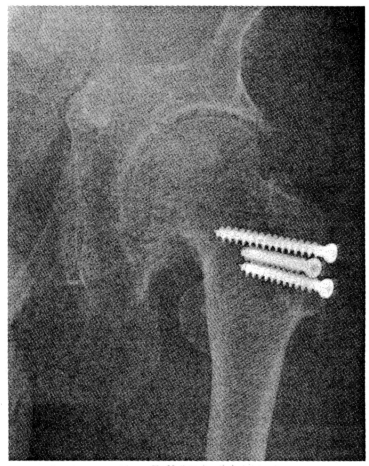

Fig. 2c

Radiographs of the left hip of a 30-year-old man a) with early-stage osteoarthritis, b) three weeks after Chiari osteotomy and c) 21 years after surgery, showing good remodelling of the acetabulum and preservation of the joint space. The patient's Harris hip score was 89 points.

without trochanteric osteotomy was used in the initial 21 hips, a posterolateral approach with trochanteric osteotomy in the second 58 hips from 1978 to 1990, and the Ollier lateral U-approach with trochanteric osteotomy in the remaining 94 hips since 1990. In 22 patients (22 hips) Chiari osteotomy was combined with an intertrochanteric varus (12 hips) or valgus (ten hips) osteotomy. If the pre-operative position of the greater trochanter was high it was advanced to the normal position, where its proximal aspect was at the level of the centre of the femoral head. Post-operative traction or cast immobilisation were not used.

Clinical evaluation was performed using the Harris hip score (HHS).[13] Pre- and post-operative clinical data were collected from the medical records. Radiological measurements included the centre-edge angle of Wiberg,[1] the acetabular head index and the acetabular angle of Sharp.[14] The acetabular head index is the same as the acetabulum-femoral head quotient described by Heyman and Herndon.[15] The level of the osteotomy was defined as correct when located between 0 mm and 10 mm from the superior osseous margin of the acetabulum on anteroposterior and lateral radiographs.[10] Sphericity of the femoral head was measured pre-operatively using Mose circle templates.[16] The head was classified as regular when its outline was in the zone defined by concentric circles spaced 2 mm apart, irregular when it was in the zone defined by concentric circles spaced 6 mm apart, and very irregular when it was in the zone defined by concentric circles spaced ≥ 7 mm apart.

**Statistical analysis.** Univariate analyses included the chi-squared test, the Mann-Whitney U test, Kruskal-Wallis test and Wilcoxon's signed ranks test where appropriate. Pearson's linear correlation coefficient (r) was used to assess correlations among various measurements. The chi-squared test was used for analyses of the clinical factors and progression of OA. Wilcoxon's signed ranks test was used for analyses of pre- and post-operative radiological factors. The Mann-Whitney U test was used for analyses of the relationship between the progression of the Tönnis grade and radiological factors, and Kaplan-Meier survival analysis was performed, with conversion to total hip replacement (THR) as an endpoint. Survival between the groups was determined by the log-rank test. A p-value $< 0.05$ was considered significant. Statistical analyses were performed using SPSS software, version 17.0 (SPSS Inc., Chicago, Illinois).

## Results

The mean pre-operative HHS was 59 points (30 to 80), which improved to 81 points (45 to 100) at the most recent follow-up or just before THR ($p < 0.001$). It improved in the pre- or early-stage OA group from 61 points (46 to 80) to 82 points (50 to 100) ($p < 0.001$) and in the advanced group from 53 points (30 to 78) to 77 points (45 to 100)

**Table I.** Comparison of patient data, clinical outcomes and radiological evaluations between pre- or early-stage and advanced osteoarthritis

| Parameters | Pre- or early-stage (Tönnis grade: 0, 1 and 2) (n = 134) | Advanced (Tönnis grade: 3) (n = 39) | p-value |
|---|---|---|---|
| Age in yrs (range) | 27.2 (9 to 54) | 35.7 (16 to 51) | < 0.001 |
| Gender (number of hips) | | | |
| Male:female | 19:115 | 5:34 | 0.971 |
| Side (number of hips) | | | |
| Left:right | 76:58 | 20:19 | 0.548 |
| Mean Harris hip score (SD) | | | |
| Pre-operative | 60.9 (6.7) | 52.9 (9.1) | < 0.001 |
| Last follow-up | 82.1 (9.2) | 76.6 (11.7) | 0.017 |
| Mean centre-edge angle[1] (°) (range) | | | |
| Pre-operative | -1.5 (-25 to 16) | -4.9 (-27 to 12) | 0.005 |
| Post-operative | 40.8 (20 to 72) | 33.0 (18 to 54) | < 0.001 |
| Last follow-up | 39.0 (15 to 70) | 32.4 (16 to 58) | < 0.001 |
| Mean acetabular head index[15] (range) | | | |
| Pre-operative | 53.8 (28 to 78) | 51.7 (32 to 65) | 0.202 |
| Post-operative | 92.7 (71 to 100) | 91.4 (72 to 100) | 0.123 |
| Mean Sharp angle[14] (range) | | | |
| Pre-operative | 50.9 (39 to 63) | 50.0 (39 to 61) | 0.276 |
| Post-operative | 38.9 (29 to 46) | 40.0 (33 to 46) | 0.142 |

**Table II.** Relationship between Harris hip scores at follow-up or just before total hip replacement and other factors

| Parameters | Correlation coefficient (r) | p-value |
|---|---|---|
| Age (yrs) | -0.062 | 0.165 |
| Duration of follow-up (yrs) | -0.073 | 0.331 |
| Centre-edge angle[1] | | |
| Pre-operative | 0.257 | 0.001 |
| Post-operative | 0.227 | 0.003 |
| Last follow-up | 0.216 | 0.004 |
| Acetabular head index[15] | | |
| Pre-operative | 0.153 | 0.044 |
| Post-operative | 0.236 | 0.002 |
| Sharp angle[14] | | |
| Pre-operative | -0.113 | 0.154 |
| Post-operative | -0.177 | 0.020 |

($p < 0.001$). Overall, 124 hips (72%) had a satisfactory result, with a HHS ≥ 80. Satisfactory results were seen in 105 hips (78%) in the pre- or early-stage group, and 19 (49%) in the advanced group (Fig. 2). The mean HHS at the last follow-up was significantly higher in 157 hips with an appropriate level at osteotomy (82 points (45 to 100)) compared with 16 hips where the level was too high or too low (76 points (56 to 100), $p = 0.019$). There was no significant difference in the hip scores at the last follow-up between groups with anterior and transtrochanteric approaches ($p = 0.300$), Chiari osteotomy alone or with a femoral osteotomy ($p = 0.434$), and regularity of the femoral heads ($p = 0.159$).

The overall mean centre-edge angle increased from -2.3° (-27° to 16°) pre-operatively to 39.1° (18° to 72°) immediately after surgery ($p < 0.001$), and this improvement was maintained at the final follow-up (37.5° (15° to 70°), $p < 0.001$). The mean acetabular head index increased from 53.3 (28 to 78) to 92.4 (71 to 100) ($p < 0.001$) and the mean Sharp angle decreased from 50.7° (39° to 63°) to 39.2° (29° to 46°) post-operatively ($p < 0.001$). There were significant differences in pre-operative, immediately post-operative and last centre-edge angles between the pre- or early-stage and advanced-stage OA groups, indicating that hips with advanced OA had more severe dysplasia pre-operatively (Table I). In the relationship between hip scores at follow-up or just before THR, hips with greater post-operative acetabular cover tended to have a higher hip score (Table II).

Progression of OA was found in 41 (31%) of 134 hips with pre- or early-stage disease. There were significant differences between groups in age at osteotomy, immediate post-operative and last centre-edge angles, post-operative acetabular head index, and post-operative Sharp angle, with or without progression of OA (Table III). This was found more frequently in patients aged ≥ 25 years (27 of 66 hips, 41%) than in those < 25 years (14 of 68 hips, 21%, $p = 0.011$). The level of osteotomy was correct in 123 hips (92%), too high in eight (6%) and too low in three (2%).

**Table III.** Comparison of data on the patients with or without osteoarthritis progression in pre- or early-stage osteoarthritis (mean, range)

| | Osteoarthritis progression | | |
|---|---|---|---|
| **Parameters** | **Yes (n = 41)** | **No (n = 93)** | **p-value** |
| Age in yrs | 29.7 (12 to 54) | 26.1 (9 to 51) | 0.047 |
| Duration of follow-up in yrs | 22.3 (10.7 to 28.3) | 20.4 (10.0 to 32.5) | 0.310 |
| Centre-edge angle[1] (°) | | | |
| Pre-operative | -2.9 (-15 to 10) | -0.9 (-25 to 16) | 0.092 |
| Post-operative | 35.2 (20 to 56) | 43.3 (21 to 72) | 0.002 |
| Last follow-up | 32.7 (15 to 54) | 41.8 (20 to 70) | 0.001 |
| Acetabular head index[15] | | | |
| Pre-operative | 52.2 (41 to 72) | 54.4 (28 to 78) | 0.098 |
| Post-operative | 89.1 (71 to 100) | 94.2 (71 to 100) | < 0.001 |
| Sharp angle[14] | | | |
| Pre-operative | 50.7 (39 to 60) | 51.0 (45 to 63) | 0.523 |
| Post-operative | 40.2 (32 to 46) | 38.4 (29 to 46) | 0.011 |

The progression of OA was more frequent in hips with an incorrect osteotomy level (eight of 11 hips) than in those in which the level was correct (33 of 123 hips, p = 0.002). Although there was no significant relationship between surgical approach and progression of OA (p = 0.171), the correct level of osteotomy was more frequently achieved through the transtrochanteric approach (109 of 116 hips) than through the anterior approach (14 of 18 hips, p = 0.020).

A total of 15 hips (9%) had undergone THR, seven (5%) of 134 hips with pre- or early-stage OA and eight (21%) of 39 with advanced OA (p = 0.003). The mean interval between osteotomy and THR was 16.4 years (5.1 to 24.5). The mean age of 33.2 years (22 to 48) in patients who underwent THR was higher than that of 28.8 years (9 to 54) in those who did not, but this difference was not significant (p= 0.062). Age at osteotomy correlated inversely with the interval between the osteotomy and THR (r = -0.563, p = 0.029). With conversion to THR as the endpoint, we found a 20-year survival rate of 93.8% (95% confidence interval (CI) 91.8 to 95.8) and a 30-year survival rate of 85.9% (95% CI 82.3 to 89.5). The 20-year survival rates in the pre- or early-stage and advanced group were 96.3% and 84.7%, and the 30-year survival rates were 91.8% and 43.6%, respectively (p < 0.001, Fig. 3).

Injury to an intra-pelvic artery by the reciprocating saw occurred in one patient. The injured artery might have been a branch of the internal iliac artery but precise identification was impossible; a vascular anastomosis was performed by vascular surgeons. The patient had a good clinical result at follow-up. One patient developed a deep infection postoperatively; it resolved after debridement. One patient with a nonunion at the osteotomy site underwent bone grafting at 18 months with a satisfactory outcome. One patient had displacement of the greater trochanter due to breakage of bio-absorbable screws. Further fixation was undertaken with metal screws and union achieved. There were no cases of pulmonary embolism or neural damage.

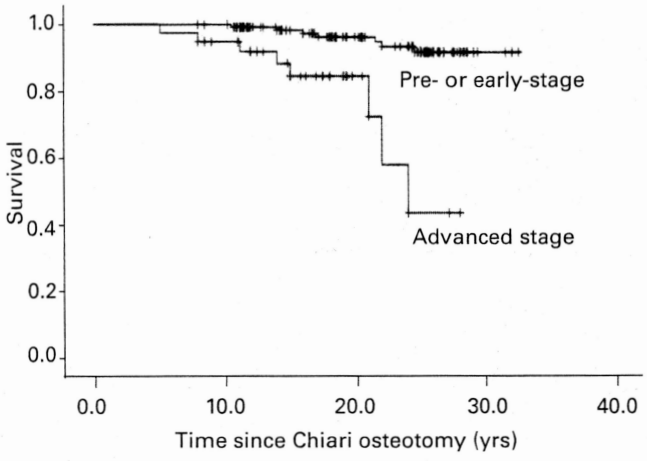


Fig. 3

Kaplan-Meier survival curves of the hips with pre- or early osteoarthritis (OA) and advanced OA after Chiari osteotomy with conversion to a total hip replacement as the endpoint.

## Discussion

There have been few reports of the outcome of the Chiari osteotomy with more than 15 years' follow-up (Table IV).[5,7-9] Most report an increase in osteo-arthritic changes with increasing length of follow-up.[4-9] Windhager et al[9] found a significant increase in degenerative changes after 20 to 34 years, and reported that the Chiari osteotomy should be performed when the patient first complains of pain. Macnicol et al[4] emphasised that long-term pelvic remodelling did not reverse the medialisation produced by the osteotomy, and that cover of the femoral head was maintained. The overall survival rates in our study are favourable compared to those of previous studies.

**Table IV.** Studies analysing the results or survival rates of hips following Chiari pelvic osteotomy

| Authors | Number of hips | Age (yrs) (range) | Follow-up (yrs) (range) | Results or survival rates |
|---|---|---|---|---|
| Kotz et al[5] | 80 | 29.7 (12 to 54) | 32 (27 to 48) | 32 hips (40%) underwent THR* |
| Windhager et al[9] | 236 | 22.3 (10.7 to 28.3) | 24.8 (20 to 34) | 21 hips (9%) needed re-operation |
| Piontek et al[7] | 34 | 13 | 30 (10 to 36) | 63% had fair or poor result |
| Rozkydal and Kovanda[8] | 130 | 29 (15 to 52) | 22.3 (15 to 30) | 50 hips (38%) underwent THR |
| Macnicol et al[4] | 215 | 15.9 (9.5) | 18 (5 to 30) | 30-year survival rate of 85.5% (THR or arthrodesis as the endpoint) |
| Ohashi et al[6] | 103 | 18.2 (6 to 48) | 17.1 (4 to 37) | Advanced degenerative change developed in 33.7% |
| | | | | One hip (1%) underwent THR |
| This study | 173 | 29 (9 to 54) | 30.2 (10 to 32.5) | 49 hips (28%) had fair or poor result |
| | | | | 30-year survival rate of 85.9% (THR as the endpoint) |

* THR, total hip replacement

Age at operation is reported to be an important factor for long-term survival.[4,5,8,9] Kotz et al[5] found no difference in the mean age at the time of Chiari osteotomy between patients who subsequently underwent THR and those who did not. However, most patients who had not undergone THR were under 30 years old at the time of the Chiari osteotomy and age at operation was inversely correlated ($r = 0.78$) with the interval between the osteotomy and THR. Windhager et al[9] reported that the results were worse with increasing age at operation, and superior results with regard to OA are most probably due to better congruency in younger patients. In a series of 130 patients, Rozkydal and Kovanda[8] reported that the average age at the time of osteotomy in 50 patients (38%) who later underwent THR was 33.7 years, compared to 24.2 years in 80 patients (62%) who did not. In the series of Macnicol et al,[4] the mean age of the patients whose hips continued to function was 18.7 years (SD 13.9) at operation, compared to 27.4 years (SD 9.7) for those requiring further surgery on the hip ($p < 0.05$). They reported that revision surgery was significantly more likely in those operated on after the age of 25 years ($p < 0.05$), and emphasised that better function was achieved if the hip was operated on earlier, preferably by the age of 20 to 25 years. In our study, we found that the mean age of patients having a THR (33.2 years (22 to 48)) was higher than in patients not having a THR, although this difference was not significant. Osteo-arthritic progression was found more frequently in patients aged 25 years or more at osteotomy (41% *vs* 21%; $p = 0.011$). Because the HHS decreases naturally with age,[17] a higher rate of progression of OA in older patients seems to be related to ageing, rather than to the technique and outcome of the osteotomy.

Previous studies have confirmed that the severity of pre-operative OA was another important factor in long-term survival.[6,8,9] Ohashi et al[6] reported that the rate of survival of hips graded as pre-osteo-arthritic was higher than in those with early OA, and Rozkydal and Kovanda[8] reported that absence of or grade 1 OA was a favourable factor for prognosis. In our study, the clinical results of hips with pre- or early OA were also significantly better than those with advanced OA. Although better results can be obtained in a dysplastic hip with pre- or early-stage OA, 31 (79%) of 39 hips with advanced OA in our study did not undergo THR. We believe that the Chiari osteotomy is indicated for young patients with advanced OA who prefer a joint-conserving procedure to THR, and accept a clinical outcome that is predicted to be less optimal than THR.

Chiari considered that the degree of medial displacement was important,[2,3] and Windhager et al[9] reported that a displacement of < 55% of the length of the osteotomy was not enough, as early post-operative deterioration was seen only in patients with inadequate correction. They emphasised that the fragments should be displaced sufficiently to provide complete cover of the femoral head, this being the most important factor for a good long-term result. Ohashi et al[6] reported a reduction in the percentage of cases with progressive change when the post-operative centre-edge angle was 30° to 60° or medial displacement 40% to 60%. Macnicol et al[6] reported that the centre-edge angle increased from 2.5° (SD 13.9) to 41.8° (SD 15.0), which was maintained at later review (38.6° (SD 16.5)) and that some lateralisation of the iliac wing becomes more likely when the procedure is undertaken in an older patient. The pelvis becomes more rigid in later life, and both the ability to shift the osteotomy and the subsequent clinical results are less good after the age of 35 years. After early adult life the osteotomy is less capable of allowing adequate displacement and the outcome becomes unpredictable. In our study, an improvement in centre-edge angle of > 37° could be obtained in hips with both pre- or early and advanced OA (Table I), indicating that the centre-edge angles were reliably increased if the osteotomy was properly performed, even in older patients with advanced OA. However, our results are representative only of Asian patients with short stature and low body mass index, and may not be applicable to Caucasian patients.

The level of osteotomy is considered an important factor influencing the outcome of a Chiari osteotomy.[3,6,7,10,11] The current good results in hips with the correct level ($p = 0.002$) indicate its importance.

The favourable long-term results reported by Kotz et al[5] suggested that medialisation of the hip joint and shortening of the hip's lever arm give long-term biomechanical advantage. Despite this, the osteotomy does not cover the femoral head with articular cartilage, unlike other reconstructive osteotomies. Peri-acetabular osteotomies provide better cover of the femoral head with acetabular articular cartilage, and mean clinical hip scores at intermediate to long-term follow-up seem superior to those of our current study.[18-23] Conversely, progression of OA after peri-acetabular osteotomy has been reported in hips without good joint congruency in abduction pre-operatively, in both early and advanced OA.[18,19,21] In Okano et al's series,[19] the results of all nine hips with early OA showing fair joint congruency post-operatively were poor. Our results of the Chiari osteotomy for hips without good congruency appear superior to those of peri-acetabular osteotomy. Macnicol et al[4] concluded that the Chiari osteotomy provides durable support for the hip when deformity of the head and acetabular distortion preclude realignment osteotomy.

We perform Chiari osteotomy for hips without good pre-operative joint congruency and peri-acetabular osteotomy for hips with good congruity. We believe this osteotomy still has a role in those cases showing poor joint congruency in abduction, even for hips with advanced OA.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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