Patient-reported outcomes following primary total hip arthroplasty in Crowe type I or II developmental dysplasia are comparable to those in Crowe type III: a case-control study of 96 hips with intermediate-term follow-up

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Abstract

Background: A few previous studies have investigated patient satisfaction following total hip arthroplasty (THA) according to the degree of pelvic deformity. This study compared patient-reported outcomes following primary THA for Crowe types II, III and I dysplasia.

Methods: This was the retrospective case-control study assessed patients who underwent primary THA by a single surgeon at a single institution from 2008 to 2016. We sent postal questionnaires to 38 patients with Crowe type III and IV dysplasia. Among the questionnaire respondents, 23 patients, excluding cases with a follow-up period of less than 1 year, were enrolled as the H group. The control group included 46 patients with Crowe type I, matched for sex, age, body mass index and surgical approach. To investigate the influence of femoral shortening osteotomy, the H group was divided according to whether or not femoral shortening osteotomy was performed. Ten patients underwent THA with femoral shortening osteotomy (FO group), while 12 patients underwent THA without femoral shortening osteotomy (N-FO group). Patient demographics, average follow-up period, surgical information, pre- and postoperative leg length discrepancy (LLD), and perioperative complications were investigated. Clinical evaluations were performed using the Japanese Orthopaedic Association (JOA) scores, 36-item short-form survey (SF-36), net promoter score (NPS), visual analogue scale (VAS), and questionnaires. The VAS and SF-36 was acquired at only final follow-up.

Results: The H and control groups were not significantly different in the postoperative JOA scores and SF-36. In the H group, VAS at the final follow-up was significantly higher, and significantly more patients felt that postoperative rehabilitation was serious, expressing that they underwent THA for LLD correction. Additionally, VAS in the FO group was higher than those in the N-FO group. Postoperative LLD was significantly greater in the H group than in the control group. Each group had the NPS of over 50.

Conclusion: The postoperative VAS was higher in Crowe type II and III dysplasia than in Crowe type I dysplasia, but there were no significant differences in the postoperative satisfaction, JOA score and SF-36. The findings may help explain the effects of THA preoperatively to patients with Crowe type II and III dysplasia.

Level of Evidence: Therapeutic Level 3b

Background

The long-term outcomes of total hip arthroplasty (THA) have been excellent [Reigstad O et al., 2008; Colo E et al., 2016]. THA is known to be associated with good satisfaction in terms of patient-reported outcome measures (PROMs) [Ethgen O et al., 2004; Jolbäck P et al., 2018]. THA for high hip dislocation was thought to be beyond surgical correction in the 1970s [Chanley J and Feagin JA, 1973]. In recent years, with the introduction of femoral shortening osteotomy, some papers have reported relatively stable outcomes [Paavilainen T et al, 1990; Thorup B et al., 2009; Wang D et al., 2017]. In general, there are various indications for THA, ranging from relatively mild pelvic deformity to severe deformity, such as

high hip dislocation. Patients with mild deformity experience pain and have restricted range of motion (ROM), which is likely to be the chief complaint [Arokoski MH et al., 2004]. On the other hand, patients with severe deformity may suffer from not only pain but also leg length discrepancy and joint contractures, as well as consequent changes in posture.

Therefore, we hypothesized that the patient-reported outcomes, expectations, and dissatisfaction for THA may vary when the chief complaint is different, depending on the degree of pelvic deformity. If the preoperative expectation is not met, satisfaction is declined [Hamilton DF et al., 2013; Dunbar MJ et al., 2013]. It is important to know what patients expect before surgery. In addition, investigating and improving the points of dissatisfaction after surgery may lead to increased satisfaction. The purpose of this study was to investigate the clinical outcomes included PROMs following THA for high hip dislocation (Crowe classification type III and IV dysplasia [Crowe JF et al., 1979]) in comparison to that for Crowe type I dysplasia.

Methods

Patients and study design

This retrospective case-control study assessed patients who underwent primary THA at a single institution from 2008 to 2016. During the study period, our institution performed 661 primary THAs. All data for this study were obtained from the hospital archive system.

We sent postal questionnaires to 38 patients (50 hips) who underwent primary THA for high hip dislocation (Crowe type III and IV dysplasia) to evaluate postoperative satisfaction. Among the questionnaire respondents, 23 patients (32 hips), excluding cases with a follow-up period of less than 1 year after THA, were enrolled as part of the high hip dislocation group (H group). For the control group, we included 46 patients (64 hips) who underwent primary THA for Crowe type I dysplasia (Figure 1). The control group was formed by recruiting data-matched controls per patient in the H group. Data matching involved matching for age (± 10 years), sex, body mass index (± 5 kg/m²), and surgical approach (posterior approach). To investigate the influence of femoral shortening osteotomy, the H group was divided according to whether femoral shortening osteotomy was performed or not. Ten patients (15 hips) underwent THA with femoral shortening osteotomy (FO group), while 12 patients (15 hips) underwent THA without femoral shortening osteotomy (N-FO group). One patient (2 hips) who underwent THA with femoral shortening osteotomy on one side and without on the other side was excluded when considering the influence of femoral shortening osteotomy.

Surgical information

All operations were performed by a single senior surgeon using a posterior approach in a lateral decubitus position under general anesthesia. For cases with acute limb lengthening greater than 40 mm at preoperative planning, THA with femoral shortening osteotomy (double chevron osteotomy) was performed (Figure 2). Femoral shortening osteotomy was performed below the level of the lesser trochanter. The longitudinally split fragments from the resected femur were placed around the osteotomy

site as a structural [allograft](#). Morselized [cancellous bone](#), which was obtained from the resected femoral head, was grafted to accelerate bone union at the osteotomy site.

Preoperative planning was performed for all THAs in both groups with the use of a computed tomography (CT)-based 3-D templating and navigation software (CT-based Hip, version 1.0 or 1.1; Stryker Navigation, Freiburg, Germany). The cup was implanted with press-fit fixation with the assistance of the navigation system. The cup was basically implanted at the level of the true acetabulum. The main target of cup orientation angle was at an anatomical inclination of 40 degrees and anteversion of 20 degrees. In both groups, all femoral components were implanted without the navigation system.

Clinical evaluations

Clinical evaluations were performed using the patient demographics, the Japanese Orthopaedic Association hip score (JOA score) [Imura S, 1995], the 36-item short-form health survey (SF-36), the visual analogue scale (VAS), and the results of the unique questionnaire that was developed for the evaluation of patient-reported outcomes. The JOA score was evaluated prior to THA and at the time of the final follow-up. The SF-36 and VAS were only evaluated at the time of the final follow-up and were enclosed in the questionnaires sent to the patients. The JOA score consists of four items: pain, ROM, gait, and activities of daily living (ADL), which are filled out by doctors. The total score is 100 points, with a higher score indicating higher hip function. In Japan, the JOA score is a common tool for clinical evaluation and is widely used [Enishi T et al., 2019]. There are reports that the JOA score and HHS are strongly correlated [Nankodo Co., 2016].

Leg length discrepancy (LLD) was measured from pre- and postoperative CT images (LightSpeed VCT; GE Medical Systems, Milwaukee, WI, USA) using the CT-based 3-D templating software (ZedHip; Lexi, Co., Ltd., Tokyo, Japan). In this study, LLD was defined as the difference in distance from the anterior superior iliac spine to the midpoint of the femoral condyle.

We obtained CT images 4 weeks prior to surgery and about 1 week after surgery.

CT images were acquired for 3-D templating preoperatively and for confirming cup position postoperatively in other studies [Ueno T et al., 2018; Ueoka K et al., 2019].

Questionnaire

The questionnaire consisted of 13 questions, which we developed for this study (Figure 3). The contents included the reason for deciding to undergo the operation, the degree of satisfaction with the surgery (with the 0-100 scale, for the patient to fill out themselves), positive or negative points about the surgery, social troubles, walking level, and VAS. The last question was “Do you still feel that surgery was the best choice for you?” Missing data on the questionnaire were completed, where possible, via telephone interviews.

Statistics

Based on a previous report [Sonohata M et al., 2018], we suggested that the minimal clinically important difference in the JOA score was 10 points and the standard deviation (SD) was approximately 15 points. Power analysis suggested that a total of 82 hips would be required to detect a clinically significant difference in the JOA score, with 80% power and 5% α error.

We analyzed patient satisfaction using even the net promoter score (NPS) based on the results of the 0-100 scale. The NPS is originally introduced across service industries to evaluate a consumer satisfaction [Reichheld FF., 2003]. That has also been used to assess the patient satisfaction of orthopaedic surgery [Hamilton DF et al., 2014; Stirling P et al., 2019]. Based on original assessment of the NPS [Reichheld FF., 2003], on the 0-100 scale, patients scoring above 90 were classified as "promoters", between 70 and 89 were classified as "passives" and under 70 were classified as "detractors". Then, the NPS was calculated by subtracting the percentage of "detractors" from the percentage of "promoters". The NPS greater than 50 was considered good outcome [Reichheld FF., 2003].

Statistical analyses were performed using a statistical software program (SPSS software for Windows, version 24.0; SPSS, Inc., Chicago, IL, USA). Group comparisons for quantitative data (e.g., patient demographics, SF-36, VAS) were performed using the unpaired t-tests, whereas categorical data (e.g., results of the questionnaire) were compared using the chi-square test or Fisher's exact test. A p-value less than 0.05 was considered statistically significant.

Results

Patient information

Patient information is summarized in Table 1. In the H group, 14 patients (19 hips) were classified with Crowe type I dysplasia, while nine patients were classified with Crowe type II (13 hips). Among those with Crowe type II, 7 hips had high hip dislocation in the gluteal muscle, and THA with femoral shortening osteotomy was performed in 11 cases (16 hips). Pre- and postoperative LLD ranged from 24.9 ± 13.9 mm to 9.4 ± 7.7 mm in the H group and from 8.1 ± 5.6 mm to 3.0 ± 2.1 mm in the control group ($p < 0.001$). Preoperative LLD in the FO group was significantly longer than that in the N-FO group, but no significant difference was detected in postoperative LLD. Postoperative LLD of one-sided THA with femoral shortening osteotomy was 18.7 ± 7.9 mm.

Complications

In the H group, infection at the central venous catheter occurred in one patient. This infection was improved by intravenous antibiotics without implant removal. Periprosthetic joint infection (PJI) occurred in one patient, and two-stage revision THA was performed. Recurrence of infection was not observed. Temporary [sciatic nerve](#) paralysis occurred postoperatively in one patient, and facial nerve paralysis occurred in one patient due to a lengthy surgery in the lateral decubitus position. They recovered within 3 months without any functional defects. Postoperative dislocations occurred in one patient, approximately 2 weeks after surgery. In the control group, intraoperative [greater trochanter chip fractures](#) were identified

in two patients, which were treated using cerclage wires and healed without further sequelae. Postoperative dislocations occurred in one patient, about 5 years after surgery. We also did not recognize obvious septic or aseptic loosening of implants that required revision THA in the radiographic evaluation at the final follow-up. In all patients in whom femoral shortening osteotomy was performed, the osteotomy site healed without any complications by the time of the final follow-up.

PROMs

In the H group, the JOA score was 45.8 ± 11.1 points preoperatively, which significantly improved to 87.4 ± 9.1 points at the final follow-up ($p < 0.001$). In the control group, the scores were 49.3 ± 10.6 and 90.8 ± 8.7 , pre- and postoperatively, respectively ($p < 0.001$). The percentage of patients with postoperative JOA improvement of 30 points or more was 84.4% (27/32 hips) in the H group and 82.8% (53/64 hips) in the control group. In both groups, there was no significant difference in the pre- and postoperative JOA scores, including the subscale (Table 1).

The SF-36, including the subscale, at the final follow-up showed no significant difference in either group (Table 1). No significant difference was detected in JOA scores and SF-36 between the FO and N-FO groups. The NPS was shown in Table 2. Each group had the NPS of over 50.

Questionnaire

Satisfaction with THA was 90.3 ± 11.3 points in the H group and 91.5 ± 12.5 points in the control group. The satisfaction rate was approximately 95.6% (22/23 cases) in the H group and 93.5% (43/46) in the control group. No significant difference was found between the groups in terms of satisfaction (Table 3). Similarly, no significant difference was detected between the FO and N-FO groups. However, satisfaction in the FO group tended to be low ($p = 0.057$) (Table 3). The VAS scores were significantly higher in the H group (14.2 ± 12.9 mm) than in the control group (9.3 ± 7.5 mm) ($p = 0.036$) (Table 3). In addition, the VAS scores in the FO group were higher than those in the N-FO group (Table 3). Hip pain was the primary reason for undergoing THA, with 65.2% (15/23 cases) in the H group and 69.6% (32/46 cases) in the control group. However, when multiple selections were possible, 52% (12/23) of patients in the H group underwent THA to correct LLD, compared to 20% (9/46) in the control group ($p = 0.006$) (Table 3). No significant difference was detected in the reason for THA between the FO and N-FO groups. With regard to the most socially troubling aspect of receiving THA, 44% (10/23 cases) of patients in the H group selected "serious rehabilitation," which was higher than the corresponding number in the control group (17%, 8/46 cases). Of the 10 patients who selected "serious rehabilitation", seven were in the FO group, significantly more than in the N-FO group. No significant difference was observed in walking ability between the groups. About 80% of patients in both groups could walk alone outdoors (Table 3).

Discussion

This study with mean follow-up period more than 5 years revealed that postoperative satisfaction, JOA scores and SF-36 of primary THA for Crowe type III and IV dysplasia were comparable to those of Crowe

type I. The height of the H group was significantly shorter than that of the control group due to the effect of high hip dislocation. In the H and FO group, intraoperative blood loss and surgery time were increased compared with the control and N-FO group. No difference was detected in perioperative complications, but results may change as the number of cases increases.

PROMs

The postoperative JOA score was favorable without any significant difference between the H and control group, and between the FO and N-FO group. The JOA score in patients with high hip dislocation was not much different from previous reports [Kawai T et al., 2014]. Although no significant difference was detected, the JOA score tended to be poor in the cases with femoral osteotomy (FO group).

The SF-36, including the subscale, at the final follow-up showed no significant difference between the H and control group, and between the FO and N-FO group. Each subscale score was as good as, or even better than, previous reports [Nilsson AK et al., 2010; Fernandez-Fairen M et al., 2011]. As described in Limitations later, the reasons for this result were considered that there may be a selection bias in this study. In other words, in this study, only the cases that responded to the postal questionnaire were enrolled, and it is possible that cases with good postoperative outcomes were selectively analyzed. However, no significant difference was detected in postoperative SF-36 between the H group and control group, which suggesting that there is no difference in postoperative PROMs depending on the degree of preoperative pelvic deformity.

Additionally, each group has the NPS of over 50 and is considered a good outcome. Hamilton et al. reported the NPS for joint replacement was 60, individual scores for total hip replacement (THR) and total knee replacement (TKR) were 71 and 49 respectively [Hamilton DF et al., 2014]. From the above, we considered that patients in the FO group with the lowest NPS (=60) in this study were also satisfied with THA.

Questionnaire

In this study, patients chose one of five options (very satisfied, satisfied, neither, dissatisfied, and very dissatisfied) at questionnaire to measure postoperative satisfaction. Then, the cases who selected "very satisfied" or "satisfied" were considered satisfied. The method of selecting one of the five options is called a five-point Likert scale and the method has good measurement properties, validity, and reliability [Dawson J et al., 1996]. Additionally, that is simple and available in many languages [Rolfson O et al., 2016]. In this study, the patient satisfaction was measured with two methods, NPS and Likert scale. Therefore, we believed that the results of patient satisfaction had high reliability.

In the H group, the VAS scores at the final follow-up were significantly higher than those in the control group, and more patients felt that postoperative rehabilitation was serious. When the H group was divided into the FO and N-FO groups, the VAS scores and number of patients who felt "serious rehabilitation" in the FO group were significantly higher. These results suggest that the FO group might have an adverse

effect on the clinical outcomes in the H group. All patients in the FO groups had Crowe type IV dysplasia and had very severe cases with acute limb lengthening greater than 40 mm. There are some reports that the intensity of early postoperative pain increases the risk of chronic postsurgical pain [Puolakka PA et al., 2010; Fletcher D et al., 2015]. THA with femoral shortening osteotomy is an effective and reliable technique [Thorup B et al., 2009; Wang D et al., 2017; Necas L et al., 2019]. However, based on this study, for patients who will undergo THA with femoral shortening osteotomy, it is desirable to explain before surgery that the postoperative rehabilitation will be more serious and there may be the possibility of persisting pain compared to normal cases.

Patients sometimes had low back pain before THA [Staibano P et al., 2014; Chimenti PC et al., 2016], which was improved after THA [Parvizi J et al., 2010; Weng W et al., 2016]. In this study, low back pain improved after surgery in all cases. It was found that THA easily improved preoperative back pain even in patients with high hip dislocation. The chief complaint of patients with high hip dislocation in the gluteal muscle is often low back and buttock pain. Therefore, low back pain caused by malalignment due to pelvic deformity or LLD should be considered as an important factor in determining the surgical indication of THA for Crowe type III and IV dysplasia.

Leg length discrepancy

There are many past reports indicating that a postoperative LLD >10 mm decreases postoperative function and satisfaction of THA [O'Brien S et al., 2010; Meermans G et al., 2011]. In the H group, patients strongly wanted to correct LLD, probably due to the large difference in preoperative LLD. However, when one-sided THA with femoral shortening osteotomy for the high hip dislocation was performed, there was a limitation to the amount of LLD correction, and postoperative LLD was often greater than 10 mm. In this study, postoperative LLD of one-sided THA with femoral shortening osteotomy was 18.7 ± 7.9 mm. Although a significant difference was not detected, it may have led to declined satisfaction in the FO group.

Limitations

This study had several limitations. First, the number of cases was small due to the rarity of high hip dislocation. In particular, there were only a few cases available for the investigation of the effects of femoral shortening osteotomy. If the number of hips is increased, there is a possibility that the results of the questionnaire will show a significant difference. However, considering that high hip dislocation was extremely rare and that the study was performed at a single institution, this study had an adequate number of hips for analysis. Second, there is a possibility that selection bias had occurred because the only patients who answered the questionnaire were enrolled in this study. This fact could artificially inflate the proportion of satisfied or unsatisfied patients. The response rates of this study were not very high at 61% (23/38 cases), however those were almost the same as the previous survey studies [Meyer R et al., 2018; Sieja A et al., 2019]. Third, the validity evaluation of the questionnaire itself in this study had not been performed in the past, and the knee condition at the time of the evaluation had not been confirmed. However, the questionnaire included the NPS, Likert scale, and VAS that have been evaluated

for their effectiveness in past reports [Hamilton DF et al., 2014; Rolfson O et al., 2016], and we considered that the questionnaire had a certain validity and reliability. Finally, preoperative PROMs, especially SF-36, had not been acquired, so the degree of improvement in surgery could not be investigated. However, the PROMs at the final follow-up were comparable between the H and control groups. Future studies that consist of more cases of high hip dislocation with a longer follow-up period are warranted in order to confirm the results of this study.

Conclusions

This study revealed that postoperative satisfaction (included NPS), JOA scores, SF-36, and walking ability of primary THA for Crowe type III and IV dysplasia were comparable to those of Crowe type I. Patients with Crowe type III and IV dysplasia strongly wanted to correct LLD, and preoperative low back pain was as easy to improve after THA as in Crowe type I. However, patients who underwent THA with femoral shortening osteotomy had higher VAS scores at the final follow-up, and more of these patients felt that postoperative rehabilitation was serious than patients without femoral shortening osteotomy for high hip dislocation. The findings of this study may help explain the effects of THA preoperatively to patients with Crowe type I and II dysplasia.

Abbreviations

ADL: activities of daily living

CT: computed tomography

JOA score: the Japanese Orthopaedic Association hip score

LLD: leg length discrepancy

NPS: net promoter score

PJI: periprosthetic joint infection

PROMS: patient-reported outcome measures

ROM: range of motion

SD: standard deviation

SF-36: 36-item short-form health survey

THA: total hip arthroplasty

VAS: visual analogue scale

Declarations

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Ethical approval and consent to participate

This study was approved by the Kanazawa University Medical Ethics Review Committee (approval number: 2718-1). Informed consent was obtained from all individual participants included in the study.

Consent for publication

We have consent for publication.

Availability of data and material

All data used and/or analysed during this study are available upon reasonable request from the corresponding author.

Competing interest

The authors declare that they have no competing interests.

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Authors' contributions

KU, TK and HT were responsible for the conception and design of the study. KU, TK, YK, DI, TA, TU, JY and YY were involved in data acquisition. KU and TK were responsible for data analysis. KU, TK, YK, DI, TA, TU, JY, YY and HT were involved in data interpretation. KU developed the first draft of the manuscript. All authors contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content. All authors have read and approved the final manuscript.

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Tables

Table 1. Patient demographics

	H group (n=32 hips)	Control (n=64 hips)	P-value	FO group (n=15 hips)	N-FO group (n=15 hips)	P-value
Number of patients	23	46	-	10	12	-
Sex (male/female)	2/21	4/42	0.686	2/8	0/12	0.195
Unilateral/bilateral	14/9	28/18	1.000	5/5	9/3	0.221
Age (years)	65.3 ± 6.3	64.5 ± 8.4	0.864	69.3 ± 4.5	60.8 ± 6.2	0.002
Height (cm)	146.1 ± 6.5	157.3 ± 10.4	0.001	142.8 ± 6.4	150.6 ± 5.4	0.007
Weight (kg)	47.9 ± 8.2	58.2 ± 12.4	0.001	48.0 ± 12.0	48.8 ± 7.1	0.849
BMI (kg/m ²)	22.0 ± 3.4	23.5 ± 3.2	0.202	23.5 ± 5.4	21.5 ± 2.8	0.284
Diagnosis (number of hips)						
Dysplasia	31	64	0.333	14	15	0.500
Other	1	0	0.333	1	0	0.500
Average follow-up period (years)	5.8 ± 2.6	5.4 ± 2.4	0.557	5.4 ± 2.8	6.3 ± 2.8	0.443
Intraoperative blood loss (mL)	465.9 ± 295.6	245.5 ± 143.0	0.001	596.0 ± 363.9	355.0 ± 212.1	0.067
Surgery time (min)	252.4 ± 108.0	149.5 ± 28.3	0.001	350.0 ± 124.4	177.7 ± 42.8	0.002
LLD-preoperative (mm)	24.9 ± 13.9	8.1 ± 5.6	0.001	31.9 ± 16.0	18.4 ± 10.0	0.026
LLD-postoperative (mm)	9.4 ± 7.7	3.0 ± 2.1	0.041	12.5 ± 9.4	7.5 ± 5.6	0.140
Complications						
Infection	2	0	0.109	0	2	0.286
Dislocation	1	1	0.716	1	0	0.455
Intraoperative fracture	0	1	0.536	0	0	-
Preoperative JOA score (points)						
Pain	15.5 ± 7.0	16.1 ± 6.5	0.670	15.7 ± 7.9	16.0 ± 6.1	0.903

ROM	10.8 ± 4.7	12.4 ± 4.0	0.081	12.4 ± 5.2	9.4 ± 3.6	0.056
Gait	8.4 ± 2.9	9.3 ± 3.4	0.242	8.0 ± 2.5	9.9 ± 3.3	0.559
ADL	10.9 ± 3.9	11.3 ± 3.5	0.641	10.8 ± 4.3	11.1 ± 3.6	0.931
Total	45.8 ± 11.1	49.3 ± 10.6	0.139	47.1 ± 12.0	45.2 ± 10.4	0.579
Postoperative JOA score (points)						
Pain	37.2 ± 3.0	37.7 ± 3.3	0.439	37.23 ± 3.1	37.3 ± 3.1	1.000
ROM	17.4 ± 2.6	18.0 ± 2.6	0.309	17.1 ± 3.3	17.7 ± 1.8	0.596
Gait	16.6 ± 3.8	17.6 ± 3.0	0.191	15.8 ± 5.0	17.7 ± 2.2	0.330
ADL	16.3 ± 4.1	17.6 ± 2.7	0.096	15.5 ± 4.8	17.1 ± 3.4	0.314
Total	87.4 ± 9.1	90.8 ± 8.7	0.080	85.7 ± 10.5	89.2 ± 7.7	0.327
Postoperative SF-36 (points)						
PF	73.3 ± 19.7	70.1 ± 22.3	0.568	75.0 ± 14.7	71.7 ± 24.1	0.696
RP	81.3 ± 19.8	79.2 ± 24.2	0.728	82.9 ± 16.8	79.7 ± 22.9	0.705
BP	72.0 ± 22.5	63.6 ± 23.2	0.158	71.0 ± 21.5	72.9 ± 24.4	0.844
GH	59.2 ± 19.3	60.5 ± 16.7	0.780	59.2 ± 19.3	60.5 ± 16.7	0.624
VT	66.6 ± 19.0	65.9 ± 15.4	0.875	68.8 ± 18.3	64.6 ± 20.2	0.610
SF	88.6 ± 18.8	87.2 ± 17.0	0.763	89.8 ± 9.4	87.5 ± 25.0	0.780
RE	83.0 ± 21.2	83.0 ± 21.3	1.000	86.4 ± 20.2	79.9 ± 22.6	0.477
MH	72.2 ± 20.7	77.5 ± 15.1	0.228	71.4 ± 21.8	72.9 ± 20.6	0.862

The control group included 46 patients (64 hips) who underwent primary THA for Crowe I dysplasia, matched for age, sex, BMI, and surgical approach.

Values are expressed as means ± SD or as numbers (n). P-values in bold indicate statistical significance (P<0.05).

H group: high hip dislocation group; FO group: femoral shortening osteotomy group; N-FO group: non-femoral shortening osteotomy group; THA: total hip arthroplasty; BMI: body mass index, LLD: leg length discrepancy; JOA: Japanese Orthopaedic Association; ROM: range of motion; ADL: activities of daily living; SF-36: Short form-36; PF: Physical Functioning; RP: Role Physical; BP: Bodily Pain; GH: General Health; VT: Vitality; SF: Social Functioning; RE: Role Emotional; MH: Mental Health; SD: standard deviation

Table 2. The Net promoter score in each group.

Groups	Promoters	Passives	Detractors	NPS
H group (n=23)	69.5% (n=16)	26.1% (n=6)	4.3% (n=1)	65
Control (n=46)	80.4% (n=37)	10.9% (n=5)	8.7% (n=4)	72
FO group (n=10)	70.0% (n=7)	20.0% (n=2)	10.0% (n=1)	60
N-FO group (n=12)	75.0% (n=9)	25.0% (n=3)	0% (n=0)	75

On the 0-100 scale, patients scoring above 90 were classified as "promoters", between 70 and 89 were classified as "passives" and under 70 were classified as "detractors". The NPS was calculated by subtracting the percentage of "detractors" from the percentage of "promoters".

NPS: Net promoter score; FO group: femoral shortening osteotomy group; N-FO group: non-femoral shortening osteotomy group.

Table 3. Questionnaire results

	H group (23 cases)	Control (46 cases)	P- value	FO group (10 cases)	N-FO group (12 cases)	P- value
Q1. The reason for receiving THA						
1. Hip pain	19	41	0.468	7	11	0.293
2. Other pain	9	14	0.470	6	3	0.192
3. Walking disorder	18	40	0.487	8	9	1.000
4. LLD	13	9	0.002	5	8	0.666
5. Limits on ROM at hip joint	16	27	0.380	7	8	1.000
Q2. Primary complaint						
1. Hip pain	15	32	0.715	6	8	0.546
2. Other pain	0	3	0.546	0	0	-
3. Walking disorder	6	5	0.161	4	2	0.348
4. LLD	1	0	0.333	0	1	0.545
5. Limits on ROM at hip joint	1	6	0.411	0	1	0.545
Q3. Satisfaction following THA						
Points	90.3 ± 11.3	91.5 ± 12.5	0.680	84.8 ± 13.2	94.0 ± 6.6	0.057
Rates, % (n/N)	95.6 (22/23)	93.5 (43/46)	0.593	90.0 (9/10)	100.0 (12/12)	0.455
Q4. Benefits of THA						
1. Hip pain subsided	19	43	0.211	7	11	0.226
2. Other pain subsided	6	12	0.071	3	3	0.583
3. Walking disorder improved	16	38	0.216	6	9	0.652
4. LLD improved	12	9	0.006	5	7	0.515
5. ROM improved	12	32	0.157	4	7	0.392
Q5. Best outcome						
1. Hip pain subsided	13	29	0.601	6	7	0.639
2. Other pain subsided	1	3	0.892	0	1	0.545
3. Walking disorder improved	6	8	0.527	2	3	0.594
4. LLD improved	2	0	0.108	1	1	0.714

5. ROM improved	1	6	0.411	1	0	0.455
Q6. Adverse outcomes						
1. Hip pain worsened	0	1	0.667	0	0	-
2. Other pain worsened	3	4	0.435	1	2	0.571
3. Walking disorder worsened	3	4	0.435	2	0	0.195
4. LLD worsened	0	1	0.667	0	0	-
5. Limits on ROM worsened	0	3	0.290	0	0	-
6. None	17	33	0.544	7	10	0.229
Q7. Worst outcome						
1. Hip pain worsened	0	1	0.667	0	0	-
2. Other pain worsened	3	4	0.435	2	1	0.429
3. Walking disorder worsened	3	4	0.435	2	0	0.195
4. LLD worsened	0	1	0.667	0	0	-
5. Limits on ROM worsened	0	3	0.290	0	0	-
6. None	17	33	0.544	6	11	0.105
Q8. Social problems after THA						
1. High treatment cost	2	2	0.596	0	2	0.286
2. Long length of stay	4	2	0.09	2	2	0.632
3. Serious rehabilitation	10	8	0.02	7	2	0.017
4. Difficult return to work	0	4	0.293	0	0	-
5. None	13	32	0.284	3	8	0.099
Q9. Worst social problem after THA						
1. High treatment cost	0	1	0.667	0	0	-
2. Long length of stay	2	2	0.596	0	2	0.286
3. Serious rehabilitation	10	7	0.01	7	2	0.017
4. Difficult return to work	0	4	0.293	0	0	-
5. None	11	32	0.079	3	8	0.099

Q10. Walking indoors						
1. No cane	20	44	0.202	7	12	0.078
2. Cane	3	2	0.202	3	0	0.078
3. A walker	0	0	-	0	0	-
4. Wheelchair	0	0	-	0	0	-
5. Not walking	0	0	-	0	0	-
Q11. Walking outdoors						
1. No cane	18	38	0.465	6	11	0.105
2. Cane	4	8	0.640	3	1	0.226
3. A walker	1	0	0.333	1	0	0.455
4. Wheelchair	0	0	-	0	0	-
5. Not walking	0	0	-	0	0	-
Q12. VAS score (mm)	14.2 ± 12.9	9.3 ± 7.5	0.036	23.1 ± 14.4	6.2 ± 8.0	0.001
Q13. THA was still the best choice?						
1. Yes	20	39	0.559	8	11	0.571
2. Not sure	3	5	0.538	2	1	0.571
3. No	0	2	0.441	0	0	-

Values are expressed as means ± SD, numbers (n), or percentages (n/N). P-values in bold indicate statistical significance (P<0.05).

H group: high hip dislocation group; FO group: femoral shortening osteotomy group; N-FO group: non-femoral shortening osteotomy group; THA: total hip arthroplasty, LLD: leg length discrepancy, ROM: range of motion; VAS: visual analogue scale.

Figures

Figure 1

Flow chart of study design. Twenty-three patients (32 hips) with THA for Crowe type $\square$, $\square$ were enrolled as the high hip dislocation group (H group). The control group was formed by recruiting data-matched controls per patient in the H group. Data-matching involved matching for age (± 10 years), sex, body mass index (± 5 kg/m²), and surgical approach (posterior approach). The H group was divided according to whether femoral shortening osteotomy was performed (FO group) or not (N-FO group). THA: total hip arthroplasty; H group: high hip dislocation group

Figure 2

A 71-year-old woman with left high hip dislocation. Preoperative (A) and postoperative (B) radiographs at 5-year follow up.

Postoperative Questionnaire for Total Hip Arthroplasty

1. Why did you decide to undergo the operation? Choose the answer that applies to you.
(Multiple selections permitted)
① Hip pain
② Other pain
③ Walking disorder
④ Leg-length discrepancy
⑤ Limits on range of motion at hip joint
2. Why did you decide to undergo the operation? Choose the one best answer in Q1. (____)
3. Provide a score for your hip surgery. (100 is best) (____) points
What is your level of satisfaction with the surgery?
① Very satisfied ② Satisfied ③ Neither ④ Dissatisfied ⑤ Very dissatisfied
4. What was good about your surgery? (Multiple selections permitted)
① Hip pain got better
② Other pain got better
③ Walking disorder got better
④ Leg-length discrepancy got better
⑤ Limits on range of motion at hip joint got better
5. What was the one best thing in Q4? (____)
6. What was bad about your surgery? (Multiple selections permitted)
① Hip pain got worse
② Other pain got worse
③ Walking disorder got worse
④ Leg-length discrepancy got worse
⑤ Limits on range of motion at hip joint got worse
⑥ None
7. What was the one worst thing in Q6? (____)
8. What social problems did you face after surgery? (Multiple selections permitted)
① High treatment costs
② Long length of stay
③ Serious rehabilitation
④ Difficult return to work
⑤ None
9. What was the one worst thing in Q8? (____)
10. Currently, how do you mainly walk indoors? (Only one selection)
① No cane ② Cane ③ A walker ④ Wheelchair ⑤ Not walking
11. Currently, how do you mainly walk outdoors? (Only one selection)
① No cane ② Cane ③ A walker ④ Wheelchair ⑤ Not walking
12. Please indicate your current level of hip pain with a mark on the line below.
(Visual Analogue Pain Score)

no painUnbearable pain

Right Hip : _____

Left Hip : _____
13. Do you still feel surgery was the best choice for you?
① Yes ② Not sure ③ No

Figure 3

Sample postoperative questionnaire for THA patients. We sent postal questionnaires to all patients enrolled in this study. The questionnaire consisted of 13 questions. The VAS was incorporated into the questionnaire. The SF-36 was enclosed in the questionnaire.