

# Controlled femoral cracking for reduction of hip arthroplasty in high riding hips: Is it safe?

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## Research Article

**Keywords:** High dislocated hip, without femoral shortening osteotomy, hip reduction, controlled femoral cracking, surgery technique

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# Abstract

**Background:** As subtrochanteric femoral osteotomy extends the operating time and increases bleeding, it is a complex surgical procedure, which exposes the patient to complications. The aim of this study was to describe the controlled femoral cracking method as a safely reduction method and to present the results of this method used in hip arthroplasty without femoral osteotomy in high dislocated hip.

**Methods:** A retrospective examination included 40 Crowe III/IV patients for whom shortening was not planned preoperatively. Femoral osteotomy was planned for Crowe III/IV patients who were expected to have >4cm lengthening according to the preoperative templating. Patients were evaluated in respect of functional results, limb length discrepancy (LLD) and complications. Of the 40 patients applied with surgery without shortening, controlled femoral cracking was required in 20 cases, and no additional procedure was required during reduction in 20 cases. The patients applied with controlled femoral cracking were evaluated in respect of functional results, operating time, actual LLD and complications.

**Results:** The patients comprised 3 males and 37 females with a mean age of  $53.7 \pm 9.54$  years. The mean follow-up period was  $38 \pm 6.54$  months (range, 24-66 months). The Harris Hip Score (HHS) was mean 45.96 preoperatively and  $89.44 \pm 6.4$  (range, 84-99) postoperatively. LLD was determined as  $3.4 \pm 0.7$ cm preoperatively and  $0.7 \pm 0.5$  cm (range, 0-2 cm) postoperatively ( $p < 0.05$ ). The final HHS was  $88.2 \pm 6.3$  in patients applied with controlled femoral cracking and  $90.3 \pm 6.5$  (range, 86-99) in those not applied with controlled femoral cracking ( $p = 0.740$ ). No increase in complications was observed in the patients applied with controlled femoral cracking.

**Conclusion:** In patients where more than 4 cm of lengthening is not expected preoperatively, arthroplasty can be successfully managed without a shortening femoral osteotomy. The controlled femoral cracking technique is safe, does not increase LLD or nerve palsy rate, and shortens operating time with less blood loss.

## Background

Although total hip arthroplasty (THA) for high dislocated hips has good long-term survival and high patient satisfaction, it is one of the most problematic orthopaedic surgeries because of the dysplastic acetabulum and femoral anatomy [1–3]. In the surgical planning of THA for high dislocated hips, there is consensus that the centre of rotation of the acetabulum should be protected and therefore, the centre of rotation should be formed in the true acetabulum [4].

The creation of the true centre of rotation entails two major difficulties, which are difficult reduction of the hip joint and the feared complication of nerve palsy as a result of lengthening the leg. Subtrochanteric femoral osteotomy (SFO) is used successfully in surgery for high dislocated hips, solving the lengthening problem by both facilitating surgical reduction and reducing the possibility of neurovascular damage [5, 6]. However, because SFO prolongs the operating time and increases the amount of bleeding, it is a

complex surgical procedure, and exposes the patient to complications such as the risk of non-union in the osteotomy line, infection, dislocation and survival of the short femoral stem [7].

Without femoral shortening osteotomy (without SFO) is a more minimally invasive surgical procedure as it shortens the operating time and there is less bleeding. The greatest advantage of the without SFO procedure is that it can eliminate leg length discrepancy (LLD). In recent years there has been seen to be an increase in studies with a large number of patients applied with the without SFO procedure in high dislocated hips arthroplasty. In studies including without SFO surgery, additional procedures have been applied both for reduction and to protect the hip biomechanics, such as lowered neck osteotomy, extensive soft tissue release, and iliofemoral distraction external fixation [8–12]. To increase the applicability of without SFO surgery in patients with a high dislocated hip, and to protect the hip biomechanics of patients with abnormal anatomy, there is a clear need for the development of new procedures.

The aim of this study was to describe the controlled femoral cracking method as a safely reduction method and to present the results of this method used in total hip arthroplasty without a femoral shortening osteotomy in dislocated high-riding hips.

## Methods

### Patients and study design

A retrospective examination was made of Crowe III/IV patients applied with total hip arthroplasty between 2011 and 2018 because of coxarthrosis based on developmental hip dysplasia. The study included 40 Crowe III/IV patients for whom shortening was not planned preoperatively and who had at least a 2-year follow-up period. Of 54 patients applied with SFO, 3 patients with a history of surgery to the same hip, 4 with severe contracture, and 1 with bilateral pathological hip, were excluded from the study. Finally a total of 40 Crowe III/IV hips to which without SFO surgery was applied were included in the study. All participants signed informed consent.

Of the 40 patients applied with surgery without shortening, controlled femoral cracking was required in 20 cases, and no additional procedure was required during reduction in 20 cases. Controlled femoral cracking applied for reduction was applied to patients with the femoral head at the acetabular cup superior level during reduction and without reduction following intraoperative femoral and acetabular preparation.

The amount of leg lengthening and actual LLD was determined by measuring the distance between the medial malleolus and the spina iliaca anterior superior (SIAS) of patients. The final clinical outcomes of the patients were evaluated with the preoperative and postoperative Harris Hip Score (HHS).

Complications were recorded as infection and dislocation. All the patients were evaluated in respect of functional results, LLD and complications. The patients applied with controlled femoral cracking were evaluated in respect of functional results, operating time, actual LLD and complications.

# Surgical technique

## Planning and acetabular preparation

Preoperative templating was applied to the patients, and component size, centre of acetabular rotation and the borders were calculated. The preoperative decision for SFO was made for Crowe type III/IV patients with > 4 cm lengthening planned according to the templating. For the other patients, without SFO surgery was planned.

With the patient in the supine position on a radiolucent operating table, a direct lateral approach was made under general anaesthesia. The head cut was made from the proximal border of the trochanter minor. The true acetabulum was reached by tracking the capsule, after which the capsule was excised. The localisation of the true acetabulum was checked with fluoroscopy, then it was exposed by clearing the surrounding soft tissues and osteophytes. The true acetabulum was targeted as the centre of rotation, and reaming was applied without medialisation or medial protrusion. A cementless press-fit acetabular cup was applied, and fixation with 2–3 screws for rotational stability. An acetabular cup of size 40–54 was used, and femoral head of 22, 28 or 32 mm, compatible with the acetabular cup. The presence of high centre of rotation was accepted as positive when the distance measured between the teardrop and the centre of rotation was > 35 mm.

## Femoral preparation and surgery technique for reduction

Controlled femoral cracking was applied to patients not applied with SFO and with femoral head at the acetabular cup superior level during reduction despite iliopsoas tenotomy. The controlled femoral cracking technique was applied by continuing trial femoral stem impaction after a prophylactic single cable was wrapped immediately below the trochanter minor. After reduction reliability was confirmed with the trial component, the real femoral component was applied. If a trochanter minor fissure was seen after application of the femoral component, a second cable was wrapped around the trochanter minor (6 patients required a second cable). After reduction, joint range of motion (ROM) and the tensor fascia were again evaluated. Tensor fascia release was applied if there was excessive tension. A cementless femoral stem was used in all patients; according to the DORR index, a Taperloc (Biomet, Warsaw, IN, USA) or a Secur-Fit Plus Max (Stryker, Mahwah, NJ, USA) femoral stem was used. It was aimed to obtain total anteversion (acetabular + femoral) of 20°-30°. The surgical technique of femoral cracking is shown in Fig. 1.

## Follow-up

Patients were mobilised on postoperative day 1 with partial weight-bearing. At the end of 1 month postoperatively, full weight-bearing was permitted. Case examples were shown in Figs. 2 and 3.

## Statistical analysis

Data obtained in the study were analysed statistically using SPSS vn. 22 software. Qualitative data were stated as number (n) and percentage (%), and quantitative data as mean, minimum and maximum values. Interobserver and intra-observer reliability was evaluated using the interclass coefficient. The Harris Hip Scores of the patients applied and not applied with controlled femoral cracking were evaluated with the MannWhitney U-test. The Chi-square test was applied to determine the relationships between the complications and groups. In the evaluation of the HHS according to the groups of additional surgical procedures, the Kruskal Wallis test was applied. Results were stated in a 95% confidence interval. A value of  $p < 0.05$  was accepted as statistically significant.

## Results

The patients comprised 3 males and 37 females (M/F: 1/12) with a mean age of  $53.7 \pm 9.54$  years. The mean follow-up period was  $38 \pm 6.54$  months (range, 24–66 months). The operated hips were left side in 23 cases and right side in 17 cases (left/right:1.5/1). The mean body mass index (BMI) of the patients was  $29.5 \pm 4.21$ . The demographic data of the patients are shown in Table 1.

The Harris Hip Score (HHS) was mean 45.96 preoperatively and  $89.44 \pm 6.4$  (range, 84–99) postoperatively ( $p < 0.05$ ). LLD was determined as  $3.4 \pm 0.7$  cm preoperatively and  $0.7 \pm 0.5$  cm (range, 0–2 cm) postoperatively ( $p < 0.05$ ). No patient had LLD of  $> 2$  cm (Table 1).

The final HHS was  $88.2 \pm 6.3$  in patients applied with controlled femoral cracking and  $90.3 \pm 6.5$  (range, 86–99) in those not applied with controlled femoral cracking ( $p = 0.740$ ).

LLD at the final follow-up examination was determined as  $0.71 \pm 0.4$  cm in patients applied with controlled femoral cracking and  $0.69 \pm 0.4$  (range, 86–99) in those not applied with controlled femoral cracking, with no statistically significant difference determined between the groups ( $p = 0.940$ ).

No statistically significant difference was determined between the groups in respect of operating time and the need for blood transfusion ( $p = 0.624$ ,  $p = 0.746$ ).

No statistically significant difference was determined between the groups in respect of the complications of dislocation, infection, or neurological damage ( $p = 1.00$ ,  $p = 1.00$ ,  $p = 0.556$ , respectively) (Table 2).

Permanent sciatic nerve palsy developed in 1 patient, and in the sciatic nerve exploration performed, there was determined to be widespread fibrosis in the nerve sheath. Tendon transfer was applied to this patient at the end of 18 months because of drop foot. In the patients with dislocation, reduction stability was obtained with constrained acetabular cup revision.

## Discussion

For many years, successful results have been obtained with the SFO procedure in high dislocated hips [13, 14]. However, in patients applied with SFO, problems are expected such as the risk of non-union in the

osteotomy line, infection, dislocation and survival of the short femoral stem in addition to a longer operating time and increased blood loss [15, 16]. Therefore, there is increasing interest from orthopaedic surgeons in without SFO procedures. In the current study of 40 Crowe III/IV patients, high functional scores were obtained without femoral shortening, and no difference was observed in complication rates such as sciatic nerve damage, dislocation and infection. Similarly no difference was observed in rehabilitation and follow-up with similar HHS scores obtained for patients in the controlled femoral cracking group.

Current literature has shown that the hip functional scores of without SFO procedures can be just as good as those of surgical procedures with SFO, and some studies have obtained better results [7, 17, 18]. Mei XL et al compared the results of patients applied and not applied with SFO and reported higher HHS in the patient group not applied with SFO. In a study by Li et al, minimally invasive surgery was planned for Crowe IV patients only, and in the without SFO group, the operating time was found to be shorter and the need for blood transfusion was significantly reduced [7]. As seen in both literature and in the current study, the without SFO procedure in high dislocated hip surgery should be seen as a successful surgical technique, which not only shortens operating time and facilitates the surgery, but also reduces morbidity.

One of the most important advantages of the without SFO procedure is that it allows treatment of LLD. Although limping and LLD is a significant postoperative complaint in high dislocated hip patients, the pain can sometimes be overcome. With the use of the without SFO procedure, LLD has been shown to be corrected to a significant degree [8–11]. In a study by Chen et al, the without SFO procedure was shown to reduce gluteal limping together with correction of LLD [19]. In a series of 38 procedures, Kawai et al reported LLD of mean 3.2 cm (range, 1–5.1 cm) preoperatively and 0.6 cm (range, 0–1.8 cm) postoperatively [8]. Similar to the Kawai study, Wu et al reported LLD correction from 4.3 cm (range, 2.5–5.5 cm) preoperatively to 1.3 cm (range, 0–1.6 cm) postoperatively. However, what amount of LLD is acceptable is not known. Benedetti et al showed that when LLD was 1–20 mm, symmetry was not impaired and hip kinematics were provided [20]. In the current study, although there were no patients with LLD < 2 cm, improvement was seen in the LLD values from  $3.4 \pm 0.7$  cm preoperatively to  $0.7 \pm 0.5$  cm (range, 0–2 cm) postoperatively.

In operations when SFO is not applied, the patient must be thoroughly evaluated in respect of the possibility of nerve damage and excessive soft tissue tension. The most feared complication of surgery without SFO is that sciatic nerve palsy could develop due to the lengthening created. Nerve damage in THA is observed mostly in the sciatic nerve at the rate of 90%. If leg lengthening of > 4 cm is required, it is recommended that the femur is shortened to prevent nerve palsy [21, 22]. To protect against nerve damage, it is recommended that preoperative traction is applied, the operation is performed under general anaesthesia, care is taken in the placement of retractors, and that the postoperative hip position is hip flexion, knee extension. Kong et al recommended the use of neuromonitorisation when necessary to protect against neurological complications [23]. The authors recommended that shortening should be applied when reduction of the true acetabulum is not possible. In the current study, the without SFO procedure was applied to patients where > 4 cm lengthening was not planned, but it can be considered

that the osteotomy decision should be made after consideration of additional intraoperative reduction methods.

Hip reduction without SFO is performed with surgical experience and the surgeon develops his own methods. The first stage in reduction is the use of muscle relaxants, for which Yan et al. recommended the intraoperative administration of additional rocuronium [12]. In the current study, surgery was applied to all the patients under general anaesthesia and with muscle relaxant. Another advantage of general anaesthesia over regional anaesthesia is that it allows the evaluation of nerve examination in the early period during patient recovery. As a more invasive reduction method, Kawai et al applied an additional femoral neck cut extending to the level of the trochanter minor in 38 patients and obtained successful results. Wu et al performed additional soft tissue loosening to patients with severe contracture and were able to obtain reduction with no shortening and up to 7 cm lengthening [10]. Lai et al applied surgery without shortening by providing lengthening with the aid of an iliofemoral external fixator. As this method was more invasive and required two surgeons, it was reported to be less favourable than other methods [11]. In a recent study, Li et al described a more minimally invasive reduction method with a Hohmann retractor [24]. In the current study, with the HHS of  $88.2 \pm 6.3$  (84–93) in the controlled femoral cracking group, no decrease was observed ( $p = 0.750$ ). The advantage of the controlled femoral cracking method described is that it can be applied in a controlled manner according to the degree of intraoperative reduction. It can be considered that by protecting the vertical offset at the same time, this did not cause pathology in the abductor arm and did not create a difference in the functional scores.

The main limitation of this study was that there was no control group for the comparison of hips without shortening. In addition, the number of patients was low and the study was retrospective. That there was no evaluation of the lower back and knees of the patients constitutes another limitation. Although a decrease in knee scores with valgus alignment in the knee joint after without SFO surgery has been reported in the literature, no study could be found which has reported the effect on the lower back. It can be recommended that further studies are planned for evaluation with gait analysis of varying lower extremity biomechanics after surgery without shortening. A strong aspect of the current study was that all the operations were performed by a single surgeon using the same procedure.

## Conclusions

In patients where more than 4 cm of lengthening is not expected preoperatively, arthroplasty can be successfully managed without a shortening femoral osteotomy. The controlled femoral cracking technique is safe, does not increase LLD or nerve palsy rate, and shortens operating time with less blood loss.

## Declarations

### Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All participants signed informed consent. The questionnaire and methodology for this study was approved by the University of Health Sciences of Turkey affiliated hospital of Keçiören HPRC with the following reference number: 43278876-929 (59. Meeting/13.02.2020)

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

The data collected and analyzed not published in the current study due to patient deprivation. The data collected and analyzed are available from the corresponding author on reasonable request.

### **Competing interests**

All authors declare they have no competing interests.

### **Funding**

None.

### **Author contribution**

Concept: Y.U.Y; Design: Y.U.Y., E.Ö.; Supervision: Y.U.Y, E.Ö.; Fundings: Y.U.Y., A.A.; Materials: Y.U.Y., A.A.; Data: Y.U.Y., A.A.; Analysis: Y.U.Y., İ.D; Literature search: Y.U.Y., M.C.O; Writing: Y.U.Y., İ.D.; Critical revision: Y.U.Y., M.A.

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## Tables

**Table 1.** Demographic data of the patients without shortening femoral osteotomy

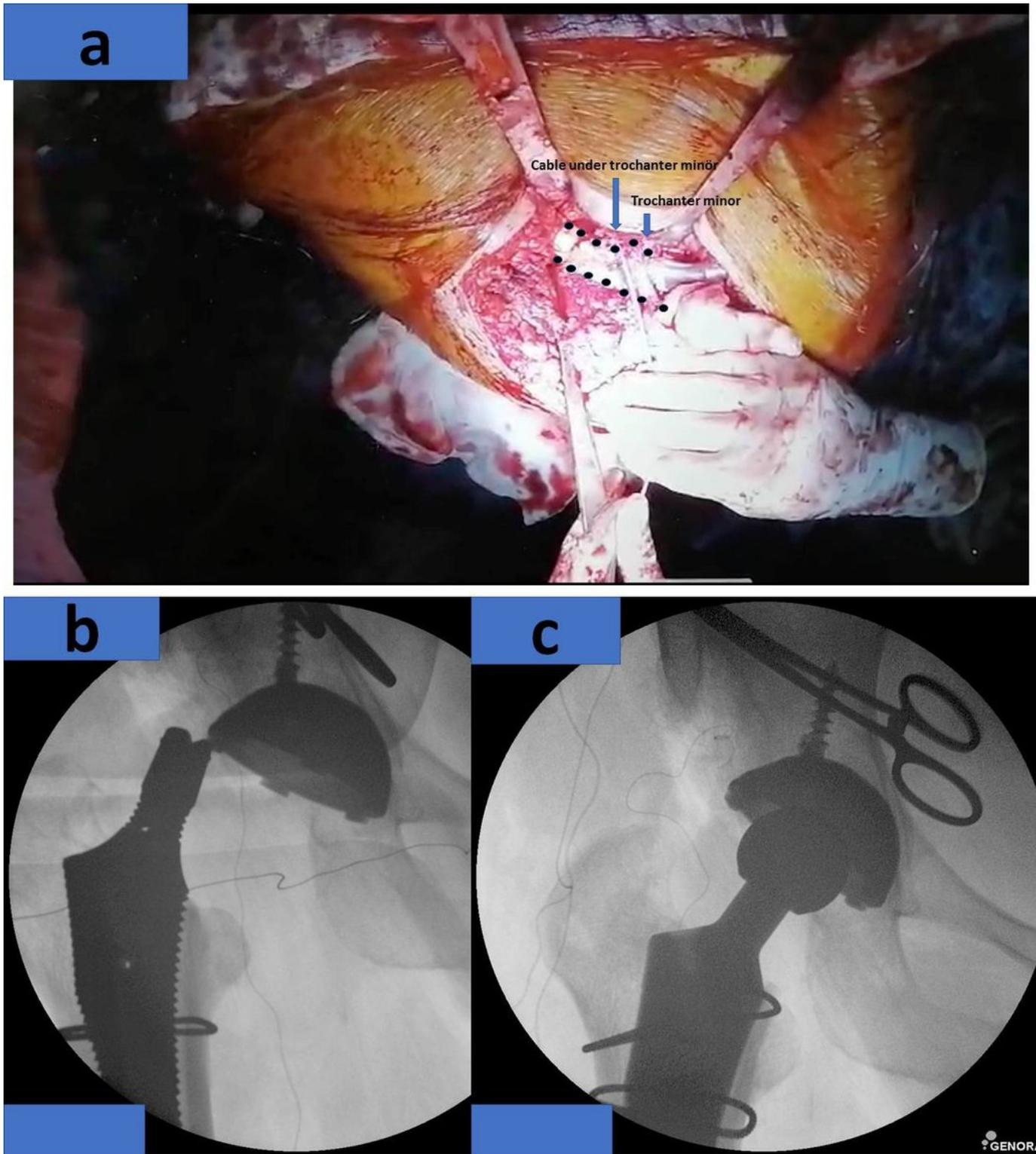
	Controlled femoral cracking	Without Controlled femoral cracking	Total (n/%)
Hips	20	20	40
Age	51.8 (32-67)	54.9 (21-74)	53.7±9.54
<b>Gender</b>			
Male	2	1	3 (7.5%)
Female	18	19	37 (92.5%)
<b>Side</b>			
Right	9	8	17 (42.5%)
Left	11	12	23 (57.5%)
BMI	30.3 (23-37)	29 (25-33)	29.5±4.21
<b>Crowe</b>			
Type 3	6	20	26 (65%)
Type 4	14		14 (35%)
<b>Hartofiladikis</b>			
B	11	20	31 (77.5%)
C	9		9 (22.5%)
Acetabular grafting	2	4	6 (15%)

Abbreviations: BMI; Body mass index

Table 2. Comparison of data obtained from patients' follow-up

	Patients	Controlled femoral cracking	Without controlled femoral cracking	p
ion	2 (5%)	1 (5%)	1 (5%)	1
	0	0	0	1
gical injury	1 (2.5%)	0	1(5%)	0.556
reoperative)	45.96	47.7	44.8	0.720
ostoperative)	89.44	88.2	90.3	0.560
ion (U/patients)	2	2	1.9	0.746
rgery time (minute)	104±20	109±20	101±10	0.624
ongation preoperative (cm)	3.41	3.63	3.22	0.234
ongation postoperative (cm)	0.71	0.71	0.69	0.940
cm)	0	0	0	

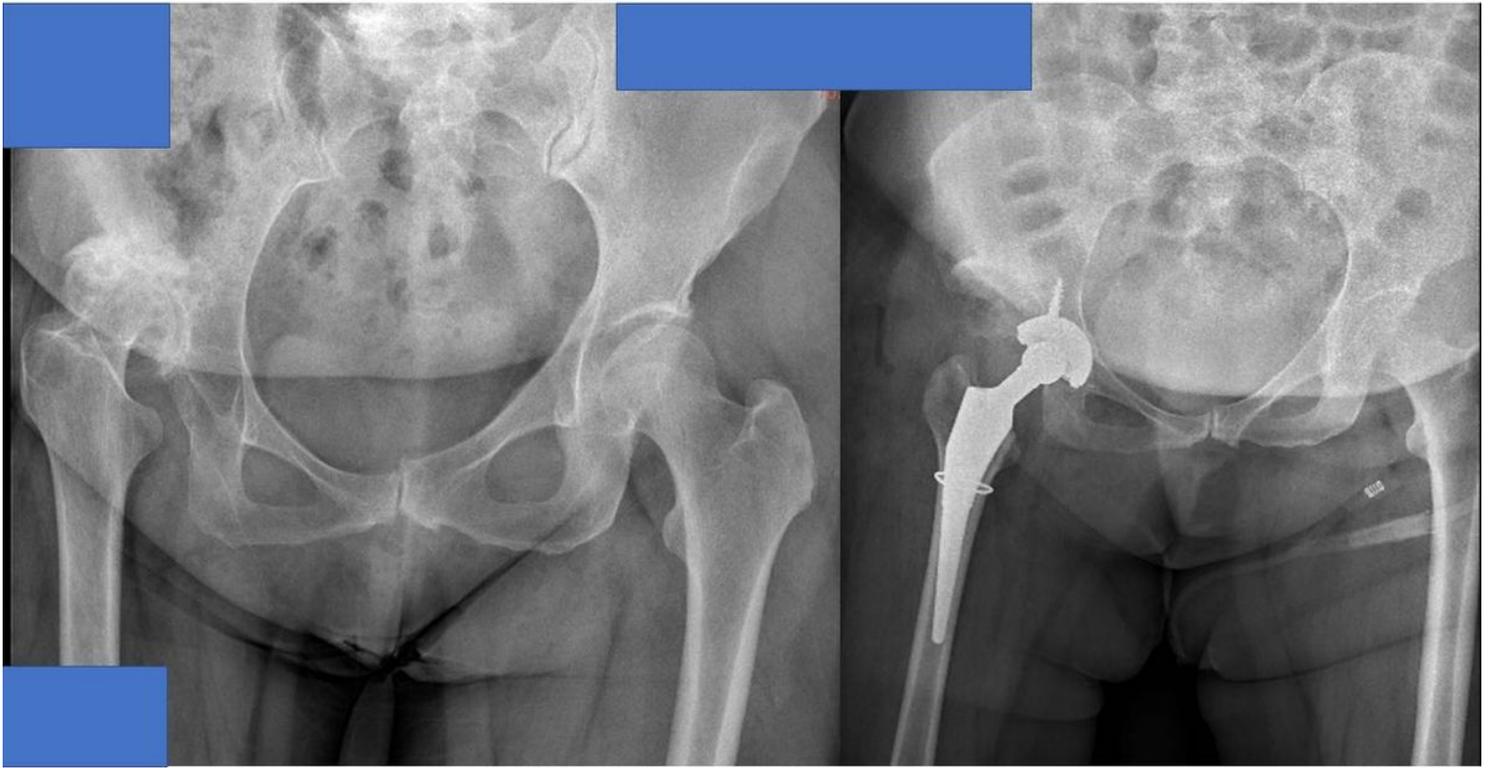
## Figures



**Figure 1**

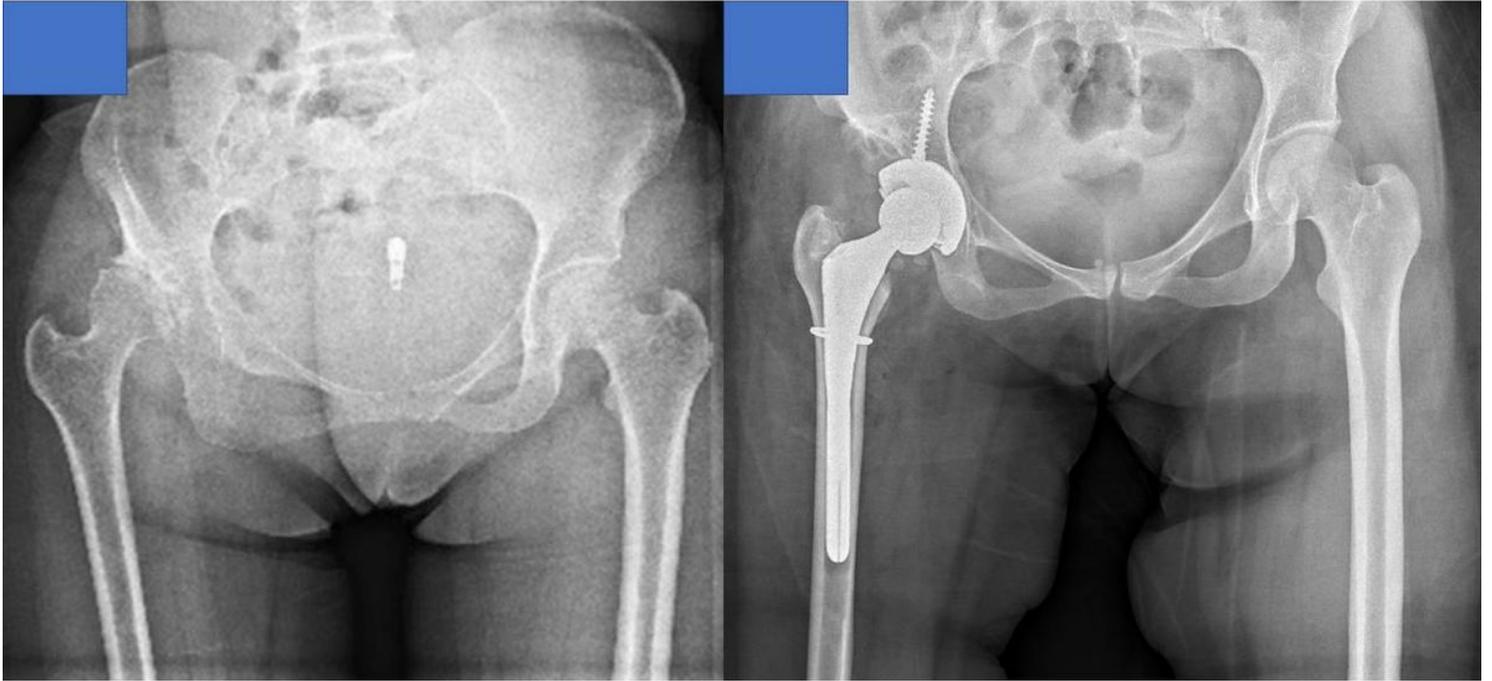
Controlled femoral cracking surgery technique ( a: The prophylactic cable was wrapped around when reduction could not be obtained with the trial femoral stem (size determined according to preoperative templating) during femoral preparation, b: After application of the cable, impaction of the trial femoral component was continued and that reduction was obtained was checked with fluoroscopy, c: after

application of the original femoral stem, a second cable was applied when there was a fissure in the trochanter minor )



**Figure 2**

Case 1: Preoperative and postoperative radiographs



**Figure 3**

Case 2: Preoperative and postoperative radiographs

## Supplementary Files

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