Reverse reaming distraction for acetabular reconstruction of chronic pelvic discontinuity

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Abstract

Introduction The acetabular distraction technique demonstrates encouraging radiographic and clinical outcomes in treating chronic pelvic discontinuity. The aim of this study is to describe a modified distraction technique and to show our results.

Methods This study identified 12 cases of chronic pelvic discontinuity undergoing primary or revision total hip arthroplasty (THA) with the technique of reverse reaming distraction between July 2015 and November 2018. All 12 patients had a minimum followup of 12 months. Radiographs were reviewed to inspect for component loosening. Clinical assessment included the Harris hip score (HHS) and an ambulatory scoring system.

Results At the time of final follow-up, no patient was revised. One patient had up to 1 cm migration of the cup in a horizontal or vertical direction and more than 20° change in the abduction angle but was asymptomatic. In the remaining 11 patients, no migration of the component was detected. Both the HHS and ambulatory score showed improvement in all patients. There were no perioperative complications. No postoperative dislocation occurred.

Conclusions Reverse reaming distraction is a feasible technique in treatment of chronic pelvic discontinuity. Sometimes it can work with the aid of augment or cup-cage construct. When both the superior and inferior portions of the pelvis achieve osteointegration into the porous metal cup, a long-term durability can be expected.

Introduction

Pelvic discontinuity is an uncommon problem in acetabular revisions or in complex primary THAs, which is defined by the absence of bridging bone between the superior and inferior hemipelvis.¹ Due to substantial bone loss associated with pelvic discontinuity, the acetabular reconstruction remains a challenging task.

Several options are available for treating pelvic discontinuity. Acute pelvic discontinuity is amenable to posterior column compression plating and implantation of conventional hemispherical acetabular cup.² Chronic pelvic discontinuity is often secondary to chronic bone loss due to osteolysis and loosening of an acetabular component,³ in which the residual bone has a poor capability of stabilizing the acetabular component and healing the discontinuity. The main management options for chronic pelvic discontinuity includes structural allograft with a cage, cup-cage construct, custom triflange acetabular component (CTAC), or acetabular distraction technique.⁴

The midterm failure of using a major column structural allograft combined with a reconstruction cage has been widely reported. It is attributed to the absence of permanent biological fixation. There are concerns about pull-out or breakage of the flanges, allograft resorption and infection.^{5,6} Consequently, the use of structural allografts has been decreasing over the last decade, and alternative reconstructive measures with cup-cage construct have been preferred, which can provide sufficient primary mechanical stability and potential of subsequent biological bone in-growth. Martin et al⁷ retrospectively analyzed four different modalities for the treatment of pelvic discontinuity, and found the five-year revision-free survivorship of the implant was best with a cup-cage construct (100%). Moreover, a CTAC based on three-dimensional (3D) CT scan can also address acetabular defects with a chronic pelvic discontinuity. However, the considerably high complication rates as literatures demonstrated limit its extensive application.⁸

Acetabular distraction technique, first described at length by Sporer et al⁹, demonstrates encouraging clinical and radiographic outcomes.¹⁰ However, to our knowledge, there has been few reports with respect to its use in other institutions than theirs. From July 2015 to November 2018, we have treated 12 chronic pelvic discontinuities by a modified distraction technique. We therefore describe our experience and report the outcomes associated with this technique.

Patients And Methods

Institutional Review Board approval was obtained. This study identified 12 cases of chronic pelvic discontinuity undergoing primary or revision THA with the technique of reverse reaming distraction between July 2015 and November 2018. All 12 patients had a minimum followup of 12 months (average, 24 months; range, 12–52 months). Within this cohort, the initial diagnosis was

osteoarthritis in 1, osteonecrosis in 7, post traumatic arthritis in 1, pathological acetabular fracture after pelvic irradiation in 1, and developmental dysplasia of the hip in 2. Before index operation, three patients had a history of periprosthetic joint infection, and one patient had a history of glucocorticoid pulse therapy for encephalitis. We evaluated preoperative radiographs according to the Paprosky classification.¹¹ Pelvic discontinuity in all cases was identified preoperatively by 3D printing model. Demographic data were summarized in Table 1.

Table 1
Demographics

Case	Initial Diagnoses	Gender	Age(year, Index Procedure)	Height (cm)	Weight (kg)	BMI (kg/cm ²)	Number of Previous Surgeries	Paprosky Classification	Failed acetabular fixation
1	DDH; Sequelae of poliomyelitis	F	51	165	60	22.0	1	IIIB	Uncemented
2	Pathological acetabular fracture after pelvic irradiation	F	58	168	90	31.9	0	-	-
3	Osteonecrosis	F	63	175	75	24.5	2	IIIB	Uncemented
4	Osteonecrosis	F	53	155	80	33.3	2	IIIA	Cemented
5	Post-traumatic arthritis; Acetabular fracture non-union	M	57	168	70	24.8	0	-	-
6	Osteonecrosis	F	75	160	70	27.3	2	IIIB	Uncemented
7	Osteoarthritis	F	68	158	50	20.0	1	IIIB	Cemented
8	DDH	F	37	163	53	21.1	1	IIC	Uncemented
9	Osteonecrosis	F	66	156	70	28.8	2	IIIB	Uncemented
10	Osteonecrosis	M	64	170	80	27.7	3	IIIB	Uncemented
11	Osteonecrosis	F	57	158	62	24.8	2	IIC	Uncemented
12	Osteonecrosis	M	55	176	80	25.8	2	IIIB	Uncemented

Surgical techniques

Surgeries were performed by two of the authors through a posterolateral approach. After exposure of the acetabulum, the discontinuity was confirmed by demonstrating movement between the superior and inferior halves of the pelvis. Granulation tissue, and any debris were cleaned to allow an accurate evaluation of the bone stock. Gentle reaming of the acetabulum was performed at the anatomical level to minimize the risk of removing a significant amount of remaining host bone. When the fossa showed a round shape as a whole, reverse reaming with an incremental size was performed with the aim of distracting the fibrous tissue around the acetabulum. The appropriate sized reamer was defined as enough to keep it and its unsupported handle in place, as well as allowing the surgeon to move the patient's pelvis as a unit by moving the handle. With severe bone defects, the reamer may not fully engage some specific regions of the acetabulum. In this situation, modular trial augments were placed within the defect to determine the optimal augment configuration and size that would support the acetabular component. (Fig. 1)

The acetabular component chosen for implantation was the same size as the last reamer. With the large-diameter, porous metal acetabular component acting as an “internal plate”, the discontinuity could be bridged and treated in distraction. Through the acetabular cup, multiple cancellous screws could be placed into the remaining ilium and ischium. Augments for primary stability are secured to host bone with screws prior to insertion of the acetabular component. Cement was used to bond the augment and the acetabular component. If the combined porous acetabular component and augments were not enough to achieve stability, an extra cup-cage technique could be carried out.

Postoperatively, all patients were allowed touchdown weightbearing with a walking aid device for the first 12 weeks and then gradual progression to bearing full weight as tolerated. Patients receive parenteral antibiotic for 5 days followed by another 7 days of oral antibiotic and also anticoagulation therapy for 4 weeks. Three patients undergoing staged treatment of prosthetic joint infection were administered prolonged antibiotic therapy.

Postoperative assessment

All patients were evaluated clinically and radiographically before surgery, at 3, 6, and 12 months post-operatively and yearly thereafter. Clinical assessment included the Harris hip score¹², which was available for all patients preoperatively and at the last follow-up visit. We also used a modified ambulatory scoring system to evaluate the patients’ ability to walk, where a score of 1 indicates independent walking and a score of 6 indicates the use of a wheelchair.¹³

The most recent follow-up radiographs were compared with the initial postoperative and serial radiographs. Independent review of the anteroposterior and lateral radiographs was performed by two reviewers to inspect for the presence of radiolucent lines, migration of the component, component loosening, and radiographic evidence of bony callus formation across the discontinuity. Acetabular component loosening was defined as greater than 10° change in the abduction angle or a change in the horizontal or vertical position of the hip centre of more than 6 mm after correction for magnification.¹⁴ Loosening of the cage and augments were determined according to Gill’s criteria¹⁵ and the measure described by Abolghasemian et al.¹⁶

Definite or probable loosening of any acetabular component was a radiological failure. Due to the observation that some component migrates early after the surgery but eventually stabilize, we considered progressive migration of the component occurring after 1 year to be a radiological failure. Failure was defined as revision of the acetabular component due to any cause, HHS improvement of less than 20 points after the surgery, or radiological failure. The pre- and postoperative HHS scores and ambulatory scores were compared using a paired Student’s t-test and Wilcoxon’s matched-pairs signed ranks test. A p-value < 0.05 denoted statistical significance. All data analysis was performed on SPSS 21.0 software.

Results

At the time of final follow-up, no patient was revised. One patient had up to 1 cm migration of the cup in a horizontal or vertical direction and more than 20° change in the abduction angle but was asymptomatic. The patient elected to continue without further intervention.(Fig. 2) In the remaining 11 patients, no radiolucent lines, migration of the component, or component loosening was detected.

Clinically, five patients denied pain in the operative hip. Four patients reported minimal pain after walking more than 1 kilometers. Two patients recovered to a normal gait without assistive devices, four patients used one crutch for long distances, one patient used two crutches at all times due to sequela of poliomyelitis and knee valgus deformity of the contralateral limb and the patient with a migrated cup used one crutch to avoid excessive weightbearing. None of the patients used a wheelchair. The mean ($\pm$ SD) improvement of the HHS was 54.5 ± 9.3 (19.9 ± 7.2 preoperatively to 74.5 ± 9.7 postoperatively)($p < 0.001$). The mean ambulatory score pre-operatively was 5.75 (5 to 6), which improved to 2.17 (1 to 5) ($p < 0.001$). There were no perioperative complications. No postoperative dislocation occurred. (Table 2)

Table 2
Clinical data and outcomes

Case	Type of revision construct	Follow-up (months)	Harris hip score (points)		Ambulatory score (points)	
			Pre-op	Post-op	Pre-op	Post-op
1	Tantalum cup(64 mm) Cup-cage Moserlized allograft	38	15	60	6	5
2	Tantalum cup(56 mm)	41	16	64	6	3
3	Tantalum cup(66 mm) Cup-cage 3D-printed titanium augment	12	13.5	72	6	3
4	Tantalum cup(60 mm) Cup-cage	13	15	72	6	3
5	Tantalum cup(64 mm)	52	30	90	5	1
6	Tantalum cup(60 mm)	14	28	81	6	1
7	Pinnacle Gription cup (72 mm)	17	21.5	65	6	3
8	Tantalum cup(56 mm) Cup-cage	33	32	82	5	1
9	Pinnacle Gription cup(72 mm)	28	22	67	6	3
10	Pinnacle Gription cup(72 mm) Gription TF augment	19	14	89	6	1
11	Pinnacle Gription cup(66 mm)	17	22	77	5	1
12	Tantalum cup(70 mm) Cup-cage	13	10	75	6	1

Discussion

There have been various reports of structural or cancellous allograft with acetabular cages in the treatment of chronic pelvic discontinuity.^{5,6,17} On the whole, literatures indicate mechanical constructs like cages appear to provide unreliable outcomes, given the potential for fatigue and late loosening. Therefore, it's critical to achieve initial mechanical stability for bone ingrowth to occur into the prosthesis both superiorly and inferiorly to bridge the discontinuity in a biologic fashion. Both cup-cage construct and CTAC showed promising survivorships.^{6,8} However, the extensive soft tissue dissection necessary for implantation of these constructs may predispose the hip to instability and increase the risk of deep infection and nerve injury. The jumbo cup combined with acetabular distraction technique, by contrast, may be a more feasible option.

Only one of our 12 patients treated with the acetabular distraction technique required revision due to acetabular component loosening. Similarly, early migration of the acetabular component was encountered in the study by Sheth et al.¹⁰ They achieved stability in a new position and remained pain free. The loosed cup in our study migrated to a more steep orientation. Asymptomatic though she is, she has to face the high risk of accelerated wear and dislocation. The failure of ingrowth of the acetabular cup might be attributed to killing effect of pelvic radiation. According to the short-term results by Berry et al¹⁸, structural allograft with cage reconstruction was more suitable for irradiated bone than cementless cup. Thus it can be inferred that adequate contact with live host bone is the prerequisite of application of jumbo cup with acetabular distraction. No migration of the component was detected in the remaining patients. In a two-center radiological analysis by Sheth et al¹⁰, 69% (22/32) of

patients demonstrated radiographic evidence of healing of the discontinuity at the time of final follow-up, which could be attributed to the effect of central compression across the discontinuity achieved by acetabular distraction technique. However, in our series, there is not enough to make connections between bony callus formation and healing of the discontinuity in the X-ray.

Reconstruction of chronic pelvic discontinuity with extensive bone loss is fraught with difficulty and complications. Compared with cup-cage construct and CTAC, jumbo cup combined with acetabular distraction technique is associated with decreased surgical time and minimization of soft tissue stripping. We did not encounter any complications. It may have something to do with the small size of our series. The distraction technique did have some complications, such as femoral artery injury, bowel injury, sciatic nerve palsy, superficial infection, dislocation and hematoma, as described by Sheth et al.¹⁰ However, the frequency of each complication was relatively lower compared with other methods^{6,8}, especially the rate of dislocation and infection. It is worth noting that all neurovascular injuries occurred in their original cohort of patients undergoing acetabular distraction. At that time, implanted acetabular cup was selected to be 6 mm to 8 mm larger than the last reamer, and the acetabulum may have been overdistacted, resulting in stress transfer to the adjacent neurovascular structures.⁹

Our method of distraction is more similar to their refined technique.¹⁰ The appropriate sized reamer was defined as allowing the surgeon to move the patient's pelvis as a unit by moving the handle. And the acetabular component chosen for implantation was the same size as the last reamer. But we do not use a dedicated extra-acetabular distractor. We consider that osteoporosis is common among Asian patients with chronic pelvic discontinuity. A stiff device will probably cause further damage to the pelvis. To avoid inadequate distraction secondary to excessive discretion, we should ensure that pelvis can be moved as a whole, without micromotion.

In some cases of severe segmental bone defect, jumbo cup with acetabular distraction technique may be not enough to achieve stability. In our study, augment was used in two patients, and cup-cage construct was used in five patients. In fact, as a supplementary measure, the acetabular distraction technique was described by some authors.^{6,19} Namely, acetabular distraction technique itself can further secure the component by the fibrous recoil. However, perhaps under some circumstances, the acetabular reconstruction cannot do without the support of a porous metal cup and augments, and even an overlying titanium cage.

There are five limitations in our study. First, our series is relatively small due to the low incidence of these difficult cases. Second, with the same reason, there is no control group for comparison with other techniques. Third, the followup is not long enough, which makes the long-term durability of this technique pending. Fourth, the retrospective design of this study is a discernable limitation. Fifth, we did not assess intraobserver variability for assessing radiographs.

Conclusions

Reverse reaming distraction is a feasible technique in treatment of chronic pelvic discontinuity. When both the superior and inferior portions of the pelvis achieve osteointegration into the porous metal cup, a long-term durability can be expected. Considering the rarity and severity of chronic pelvic discontinuity, multicenter and large sample study should be made.

Abbreviations

THA: Total hip arthroplasty; HHS: Harris hip score; CTAC: Custom triflange acetabular component; 3D: Three-dimensional; BMI: Body mass index

Declarations

Authors' contributions

JS: Analyzed the data, Wrote the manuscript.

MN: Study co-ordinator, Assessed the radiographs, Wrote the manuscript.

HM: Study co-ordinator, Assessed the radiographs.

YD: Assessed the radiographs, Analyzed the data.

JS: Follow up the patients, Collected the data, Analyzed the data.

JC: Participated in the design of the study.

YZ: Participated in the design of the study, Performed the surgery.

GZ: Created the concept, Performed the surgery, Wrote the manuscript.

All authors read and approved the final manuscript.

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Availability of data and materials

The dataset supporting the conclusions of this article is included within the article.

Ethics approval and consent to participate

This study was approved by the Ethics Committee and in accordance with the standards of the National Research Council. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

(a) Intraoperative confirmation of the pelvic discontinuity. (b) The acetabulum engaged by the reamer and moved as a unit.

Figure 2

Serial radiographs of a patient with pathological acetabular fracture after pelvic irradiation. (a) Preoperative X-ray. (b) Immediate X-ray after surgery. (c) Migration of the cup observed at 1.5 years after surgery. (d) No intervention of the loosened cup due to no symptom and total hip arthroplasty of contralateral hip.