Original Article

Long-term Outcome of Multiple Small-diameter Drilling Decompression Combined with Hip Arthroscopy versus Drilling Alone for Early Avascular Necrosis of the Femoral Head

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Abstract

Background: Avascular necrosis of femoral head (AVNFH) typically presents in the young adults and progresses quickly without proper treatments. However, the optimum treatments for early stage of AVNFH are still controversial. This study was conducted to evaluate the therapeutic effects of multiple small-diameter drilling decompression combined with hip arthroscopy for early AVNFH compared to drilling alone.

Methods: This is a nonrandomized retrospective case series study. Between April 2006 and November 2010, 60 patients (98 hips) with early stage AVNFH participated in this study. The patients underwent multiple small-diameter drilling decompression combined with hip arthroscopy in 26 cases/43 hips (Group A) or drilling decompression alone in 34 cases/55 hips (Group B). Patients were followed up at 6, 12, and 24 weeks, and every 6 months thereafter. Radiographs were taken at every follow-up, Harris scores were recorded at the last follow-up, the paired *t*-test was used to compare the postoperative Harris scores. Surgery effective rate of the two groups was compared using the Chi-square test.

Results: All patients were followed up for an average of 57.6 months (range: 17–108 months). Pain relief and improvement of hip function were assessed in all patients at 6 months after the surgery. At the last follow-up, Group A had better outcome with mean Harris' scores improved from 68.23 ± 11.37 to 82.07 ± 2.92 ($t = -7.21$, $P = 0.001$) than Group B with mean Harris' scores improved from 69.46 ± 9.71 to 75.79 ± 4.13 ($t = -9.47$, $P = 0.037$) (significantly different: $t = -2.54$, $P = 0.017$). The total surgery effective rate was also significantly different between Groups A and B (86.0% vs. 74.5%; $\chi^2 = 3.69$, $P = 0.02$).

Conclusion: For early stage of AVNFH, multiple small-diameter drilling decompression combined with hip arthroscopy is more effective than drilling decompression alone.

Key words: Avascular Necrosis of Femoral Head; Core Decompression; Hip Arthroscopy; Long-term Outcome; Multiple Small-diameter Drill Decompression

Introduction

The pathogenesis of avascular necrosis of femoral head (AVNFH) has not been fully understood.[1-3] The AVNFH typically presents in the young adults and will quickly progress to femoral head collapse and arthritic changes in the absence of treatments.[4] Therefore, hip joint preservation surgery should be considered to prevent the collapse of the femoral head or at least postpone the need for a hip arthroplasty.[3,5] The interventions include core decompression, osteotomies, and nonvascularized or vascularized bone grafting.[6] However, osteotomies and bone grafting can cause severe trauma, which further undermines the femoral head blood

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supply system and worsens the ischemic conditions in the femoral head. Simultaneously, after the above operation, the patient needs prolonged the time of external fixation, which will delay the recovery of the joint's function, and the postoperative effect is unsatisfactory.[7] Core decompression is now the most frequently used procedure and offers effective results,[2] indications for core decompression are strictly limited to the early stages of AVNFH before femoral head collapse,[8] it is a minimally invasive surgery can achieve the same effect as open surgery, and the technique has gradually diversified into single large-diameter drilling and multiple small-diameter drilling with or without bone grafting (either vascularized or nonvascularized).[9,10] Some authors reported that the rate of successful core decompression is up to 71%,[11] but others have shown that decompression has a high failure rate.[12] The optimum treatment in the early stage of AVNFH is less clear. With the development of arthroscopy techniques, hip arthroscopy is widely used in diagnosis and therapy of AVNFH.[13,14] The aim of this study was to analyze the efficacy of multiple small-diameter drilling decompression combined with hip arthroscopy for the diagnosis and treatment of precollapse AVNFH in comparison to drilling alone.

Methods

Ethical approval

All participants gave informed consent for the intervention. The study was approved by the Ethics Review Board of the General Hospital of People's Liberation Army, China. Data are available from the General Hospital of People's Liberation Army Data Access.

Study design and setting

This was a retrospective analysis of case series of ANFH. The study included records of 387 AVNFH patients, including 183 surgical interventions during 2006 and 2010. Among surgically treated patients, 60 (32.8%) were eligible for this study. The inclusion criteria were small- or medium-sized Stage I or Stage II (early stage) osteonecrosis assessed using standard radiographs or magnetic resonance imaging (MRI). Exclusion criteria were radiographic evidence of collapse (Stage III or greater), traumatic AVNFH, acetabular dysplasia-induced AVNFH or complicated with consumptive diseases. During the study, multiple small-diameter drilling decompression combined with arthroscopic (Group A) was used to treat early stages of AVNFH patients with obvious joint effusion, and multiple small-diameter drilling decompression alone (Group B) was used to treat early stages of AVNFH patients with little or no joint effusion. In this study, there were 26 patients/43 hips in Group A, 34 patients/55 hips in Group B. Surgeries were performed by same surgeon. At the final follow-up, range of movement (ROM) and functional scores were assessed.

Radiological criteria of patients' selection

Radiographs and MRI were used to diagnose and define the stage of AVNFH. Fluoroscopy, plain computed tomography (CT) scanning, and MRI of both hips in frontal and frog positions were performed. MRI was used to identify joint effusion and the size of osteonecrosis. Patients with small- or medium-sized Ficat Stage I or II osteonecrosis on radiographs and ARCO Stage I or II on MRI were included in the study. Patients of the early stage on MRI, but big-sized osteonecrosis observed under arthroscopic were also excluded from the study. Among the 183 surgically treated patients, a total of 123 patients, including 72 with radiographic evidence of collapse (Stage III or greater), 7 with evidence of collapse under arthroscopic, 19 traumatic AVNFH, 25 acetabular dysplasia-induced AVNFH were excluded from the study.

Intervention detail

In Group A, epidural anesthesia and a traction bed were used. Patients were placed in the modified supine position with moderate traction on the hip joint. All surgeries were performed using a minimum of 2 portals (standard anterolateral and mid-anterior). Needle localization was used to establish the portal and penetrate the capsule at the 2 o'clock position under the guidance of a C-arm image intensifier; then, physiological saline was injected into the hip articular cavity [Figure 1a and 1b]. Arthroscopy began in the anterolateral portal and then switched to the mid-anterior portal. The mid-anterior portal is the best position to observe the anterosuperior femoral head which is the most common site of AVNFH. The femoral head was probed to assess the areas of necrosis under both fluoroscopy and arthroscopy. The articular surface was evaluated and probed for any damage, softening, or delamination. Labrum fixation or resection and cartilage debridement by vaporization were performed intraoperatively. If synovitis of the cotyloid fossa was present, a synovectomy was performed using electrocautery. If cartilage softening or delamination was present, a chondroplasty or microfracture was performed according to the size, stability, and depth of the lesion.[15] These procedures are typically performed through the mid-anterior portal while visualizing through the anterolateral portal [Figure 1c–1f].

Multiple small-diameter drilling decompressions were then performed using a 3-mm Kirschner wire inserted laterally and percutaneously under the guidance of C-arm. The pin was advanced until it abutted the lateral cortex in the metaphyseal region opposite the superior portion of the lesser trochanter. The femur was penetrated, and the pin was advanced through the femoral neck into the femoral head into the site of the lesion (as determined from preoperative X-ray or MRI assessment). When the pin had been advanced to the subchondral area, it was removed and advanced in a different direction to the necrotic area. Depending on the size of the lesion, the femoral head was drilled 3–5 times in different directions, distributed in a fan-shape, through one common entry point. During each step, arthroscopy was maintained in the anterolateral (AL) portal and was focused on the articular side of the necrotic area to ensure that the subchondral bone and articular cartilage were not violated. After drilling, the pin was removed, and wound closed by simple bandage or a single nylon suture [Figure 1g and 1h]. In Group B, drilling

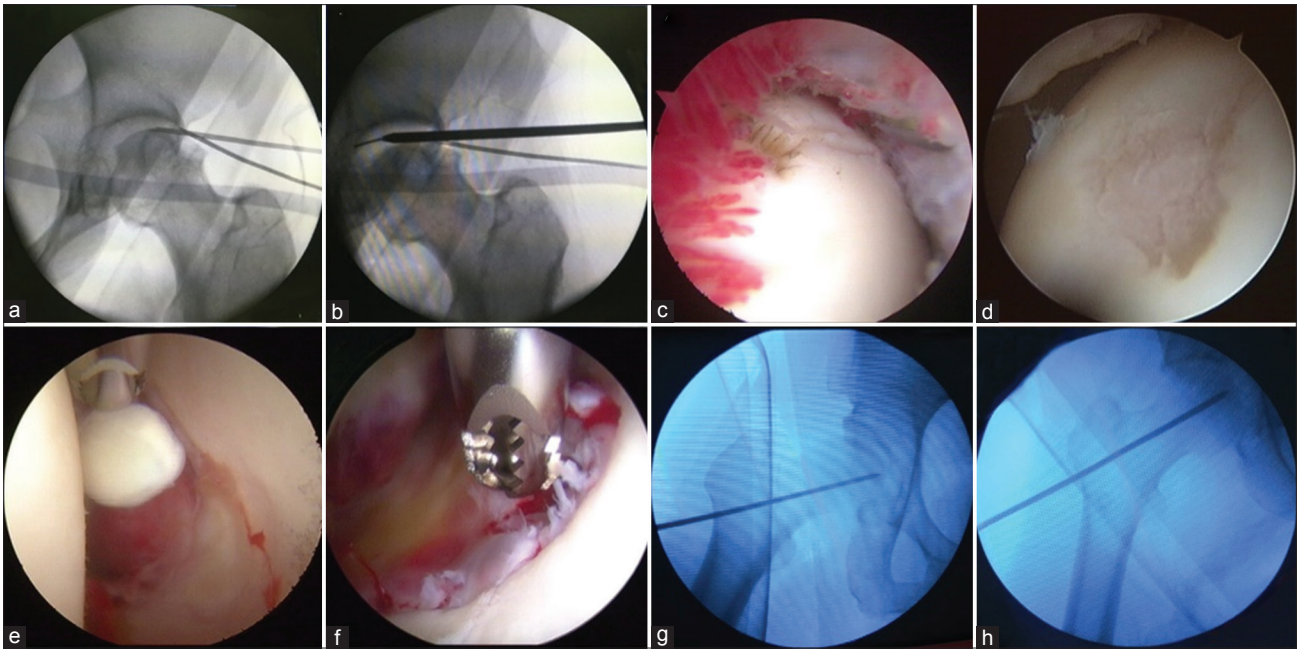

Figure 1: Surgery procedure and observations under arthroscopy. (a and b) Locating hip joint under C-arm guidance before putting in arthroscopy; arthroscopy findings: (c) Synovial hyperplasia and cartilage damage; (d) Cartilage exfoliation; (e) Corpus liberum; (f) Clean the hyperplastic synovial; (g and h) Multiple small-diameter drilling decompressions under C-arm guidance.

decompression was performed as described above without traction and arthroscopy.

Postoperative care, outcome measures, and follow-up

The patient was allowed touch-down weight bearing with crutches for the first 6 weeks postoperatively, thereafter, they were gradually allowed to return to weight bearing as tolerated. Full weight bearing was achieved at 3 months. After 6 weeks, patients were encouraged to start painless active ROM exercises.

Radiographs were obtained after surgery to evaluate the situation of the femoral head. Patients were followed up in the outpatient department at 6, 12, and 24 weeks, and every 6 months thereafter. Due to the relatively higher cost, CT and MRI scans were not used as a regular examination during postoperative follow-up. Instead, frontal and lateral radiographs were taken at every follow-up to assess the progression of collapse and no special image views were used. Progression of collapse was assessed by an observer (HZ) not involved in patient care. Any collapse detected on plain radiographs during follow-up was defined as a radiologic failure. At the final follow-up, a modified Harris Hip Scoring system was assessed by one observer (KT) independent from the treating team through a Questionnaire (supplementary material).[16] The observers are coauthors working in our department, and clearly know the disease, the surgery and the scoring system.

All these data were retrieved from our institutional database through chart review. With scores >90 points rated as excellent results, 80–90 points as good results, 70–80 points as fair results, and <70 points deemed a clinical failure. Complications were assessed through chart review by one observer (YM) other than the operating surgeon. Patients who required additional procedures, such as osteotomy, bone grafting, repeat core decompression, or total hip arthroplasty (THA), were also considered clinical failures. Clinical success was defined as a Harris Hip Score ≥80 points with no further operative procedures.

Statistical analysis

Statistical analysis was performed with SPSS software (version 17.0; SPSS Inc., Chicago, IL, USA). Data were expressed as mean ± standard deviation (SD). The paired *t*-test was used to compare the postoperative Harris scores. Independent-samples *t*-test was used to compare the quantitative data between the two groups, whereas the qualitative data of the two groups were compared using the Chi-square test. Statistical significance was set at $P < 0.05$.

Results

All sixty patients had a successful operation. Both Group A and B had well matched, age, gender, risk factors for hip necrosis, stage, Harris score, and postoperative follow-up was similar in two groups ($P > 0.05$) [Table 1]. No serious intraoperative complications, or early postoperative complications, such as infection, thrombosis and joint fibrosis, or adhesions, happened in any patient. Hip pain symptoms were relieved in 6 months on average after the operation, and hip ROM and function improved significantly.

Patients were followed up for an average of 57.6 months (17–108 months). At the final follow-up, the Harris scores were significantly improved. In Group A, the mean Harris' scores improved from 68.23 ± 11.37 preoperatively to 82.07 ± 2.92 postoperatively ($t = -7.21$, $P = 0.001$). In Group B, the mean Harris' score improved from 69.46 ± 9.71 preoperatively

to 75.79 ± 4.13 postoperatively (t = −9.47, P = 0.037; Table 2). Difference between two groups' postoperative scores were significant (t = −2.54, P = 0.017). The scores of each stage also improved, there were significant differences of the postoperative score in Stage II patients between the two groups (t = −6.31, P = 0.024), but there were no significant differences of the postoperative score in Stage I patients between the two groups (t = −2.79, P = 0.562).

In Group A, the postoperative follow-up X-rays showed one hip collapse in Ficat Stage I, and 5 in Ficat Stage II. The total success rate of surgery was 86.0% (37/43), and the rates for Stage I and II patients were 91.7% and 83.9%, respectively. In Group B, 3 Stage I hips collapsed (at 1 year) and 11 Stage II hips collapsed after the surgery. The total success rate of surgery was 74.5% (41/55), and the success rates for the Stage I and II patients were 82.4% and 71.1%, respectively. The difference in success rates between the two groups was significant (χ^2 = 3.69, P = 0.02). In addition, the differences in the success rates between the Stage I patients (χ^2 = 2.49, P = 0.017) and between the Stage II patients (χ^2 = 3.24, P = 0.04) of the two groups were significant. The THA was performed on all patients with collapsed hips during follow-up [Figures 2 and 3].

Discussion

All 60 patients had a successful outcome after multiple small-diameter drilling decompression combined with arthroscopy (Group A) and drilling alone (Group B) for ANVFH without serious complications. Pain relieved in 6 months with significant improvement in hip ROM and function. The single large-diameter drilling decompression has a failure rate of 60%,[12] which may be due to the weakening of the mechanical strength of femoral head, causing proximal femoral fractures, or femoral head collapse. Furthermore, it is difficult to completely decompress the necrosis by single, inaccurate decompression position.[17] In this study, multiple small-diameter drilling in fan-shape was used to decompress the necrotic area. This method of drilling effectively reduces the pressure of femoral head, and still maintain the supportive role of the subchondral bone to avoid fractures or collapse of the femoral head.[9,11] Mont *et al*.[11] also reported a 71% success rate in multiple small-diameter drilling at an average follow-up of 2 years.

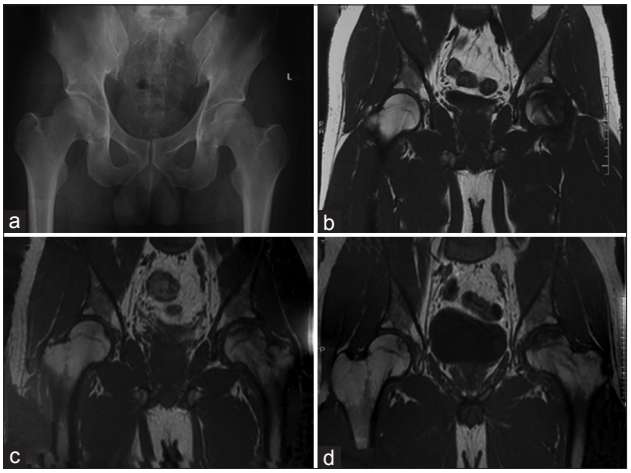

Figure 2: Images of a 36-year-old male. (a) A preoperative radiograph and (b) MR image showed AVNFH in the left femoral head; (c and d) MR image is respectively 17 months and 38 months after the surgery showed there were not obvious deteriorate AVNFH compared with the preoperative radiograph and MRI. AVNFH: Avascular necrosis of femoral head; MRI: Magnetic resonance imaging; MR: Magnetic resonance.

Table 1: Comparison of the patients' data of multiple small-diameter drilling decompression combined with hip arthroscopy (Group A) and drilling alone (Group B) of AVNFH

Characteristics	Group A	Group B	*P*
Total number (patients/hips), *n*	26/43	34/55	0.079
Gender (male/female), *n*	15/11	18/16	0.725
Age (years), mean ± SD (range)	37.4 ± 10.3 (21−55)	35.2 ± 11.8 (23−52)	0.852
Factors (alcohol/steroid/idiopathic), *n*	19/15/9	24/18/13	0.573
Stage (I/II), *n*	12/31	17/38	0.062
Harris score, mean ± SD	68.23 ± 11.37	69.46 ± 9.71	0.179
Follow-up period (months), mean ± SD (range)	61.4 ± 5.7 (21−108)	53.9 ± 4.1 (17−89)	0.463

AVNFH: Avascular necrosis of the femoral head; SD: Standard deviation.

Table 2: Harris score of patients at Stages I and II in two groups of AVNFH at pre- and post-operation

Groups	Preoperative	Last follow-up	*t*	*P*
Group A				
Stage I (*n* = 12 hips)	73.24 ± 1.74	84.63 ± 1.26	−6.71	0.016
Stage II (*n* = 31 hips)	51.33 ± 2.74	80.03 ± 5.36	−12.04	<0.001
Group B				
Stage I (*n* = 17 hips)	73.89 ± 2.18	83.55 ± 1.96	−2.76	0.028
Stage II (*n* = 38 hips)	52.62 ± 2.75	71.41 ± 2.17	−7.54	0.001

The data are shown as mean ± SD. AVNFH: Avascular necrosis of the femoral head; SD: Standard deviation.

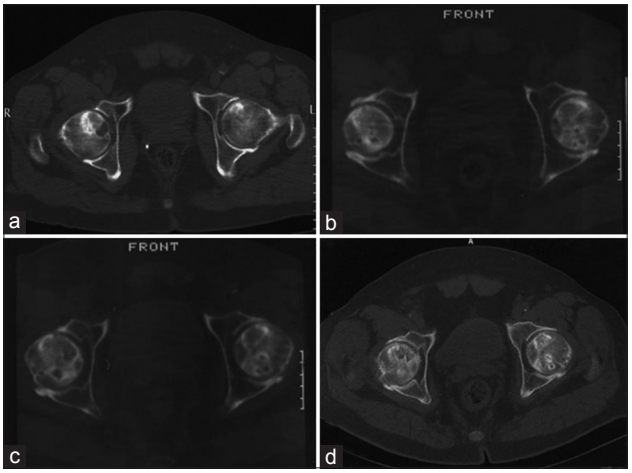

Figure 3: Images of a 49-year-old male: (a) A preoperative CT image showed AVNFH in bilateral femoral head; (b) CT image is 22 months after the surgery showed there were not obvious deteriorate AVNFH compared with the preoperative CT; (c and d) CT image is respectively 49 months and 96 months after the surgery showed obvious deteriorate AVNFH compared with the preoperative CT, but there were not collapsed. AVNFH: Avascular necrosis of femoral head; CT: Computed tomography.

Studies have shown that accurate staging is essential in choosing appropriate treatment for AVNFH.[12,17,18] The plain radiographs and MRI can diagnose and stage AVNFH,[19,20] but they are suboptimal to detect early articular cartilage damage. By contrast, hip arthroscopy provides direct observation and also helps to evaluate the size of the damaged articular surface,[14] and accurately determine the stage.[21] Sekiya *et al*.[21] reported that MRI could only show 36% of the damage observed by hip arthroscopy, and now hip arthroscopy has evolved as the gold standard to diagnose intra-articular hip pathology.[22] Therefore, hip arthroscopy can improve overall diagnostic accuracy by detecting pathologies not evident in MRI or plain radiography and can help surgeons identify patients with significant joint damage who might not benefit from core decompression.[10,23] Under arthroscopy, we found synovitis changes depending on the degrees of osteonecrosis in different stages, such as synovial tissue hypertrophy, hyperemia, and edema, the morphology of femoral head and the cartilage damage also had corresponding changes. McCarthy *et al*.[24] and Ruch *et al*.[13] also described their arthroscopic observations of AVNFH patients, and found several cartilage particles, lip injuries, synovitis, and other changes in the joint. Our findings are in support that the AVNFH is not simply pathological AVNFH but a total joint disease.

Therefore, in the treatment of AVNFH, besides the decompression of the femoral head, the secondary pathological changes in the hip cavity should also be treated.[25] In our operations, hip arthroscopy was helpful to directly visualize the condition of joint, and we could clear the hypertrophy and synovial edema accurately. Inflammatory substances, such as corpus liberum, cartilage degradation particles, and other debris, were removed by rinsing with physiological saline. This helps to reduce the intra-articular pressure and improve the joint's internal environment,[26] removes the factors that affect normal joint activity, improves functions of the joint and block the vicious inflammatory cycle.[27] Arthroscopy can assist C-arm-guided decompression, and significantly decrease the rate of penetrating cartilage.[14,18,28,29] Thus, the treatment of early stage of AVNFH is a comprehensive therapy and multiple small-diameter drilling decompression combined with hip arthroscopy is an important modality.

In this study, preoperative plain radiographs/MRI showed that Ficat stage I/ARCO Stage I patients have less joint effusion, patients with Stage II are beginning to show joint effusion, and the amount of fluid gradually increases with the development of disease. Based on our results, we summarize the indications for hip arthroscopy in the treatment of early stage of AVNFH as: (1) failure of conservative treatment; (2) MRI showing significant synovial hyperplasia, effusion, and articular cartilage damage; (3) corpus liberum in articular cavity or labrum injury with mechanical symptoms. Conversely, some patients are not suitable for hip arthroscopy: (1) no joint effusion; (2) infection; (3) obesity that may affect the introduction of arthroscopy into the joint cavity; and (4) hip joint stiffness or rigidity, which makes it difficult to retract.

However, the operation time of the combined treatment was longer than drilling alone. Hip arthroscopy is normally safe, but it is not a procedure without associated complications.[30] A recent meta-analysis described an overall 4% complication rate of hip arthroscopy surgeries,[31] such as injury of perineal skin, nerve palsy, vascular injury, compartment syndrome, hematoma, and infection.[31,32] Scher *et al*.[33] reported a patient developed to AVN after an examination through hip arthroscopy, and these authors thought that it was caused by excessive traction weight and time. In our study, all operations were performed by an experienced surgeon, and we marked the surface projection of the important nerves and vessels preoperatively. We always chose a mid-anterioror anterolateral safer surgical approach, unlike anterior approach, which may damage the femoral artery and femoral nerve.[21] During operation, the traction weight and time of traction should be taken into account to prevent injury of perineal area.[34] At follow-ups, we had no serious complications.

Postoperative rehabilitation training is important for the recovery of the patient's hip function. Song *et al*.[9] in a comparative study concluded that the outcome of core decompression surgery is related to the time of postoperative nonweight bearing. Therefore, the rehabilitation plan should be determined according to the specific circumstances of the patient's clinical symptoms.

In conclusion, based on long-term follow-up, we can conclude that multiple small-diameter drilling decompression combined with hip arthroscopy is more effective in the treatment of early stage of AVNFH than drilling decompression alone. The combined approach of multiple small-diameter drilling decompression and arthroscopy had better pain relief,

improved hip function, effective in slowing down the process of femoral head necrosis, and delayed the need for THA.

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Supplementary information is linked to the online version of the paper on the Chinese Medical Journal website.

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Conflicts of interest

There are no conflicts of interest.

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