Arthroscopic Hill-Sachs Remplissage

A Systematic Review

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Background: Failure to address humeral osseous defects during arthroscopic stabilization surgery for glenohumeral instability leads to an increased rate of recurrence. Arthroscopic remplissage has been proposed as a treatment option for substantial Hill-Sachs lesions. The aim of this systematic review was to examine the outcomes of the remplissage procedure for the treatment of anterior glenohumeral instability of the shoulder with a humeral head defect.

Methods: A systematic literature review was performed to evaluate the outcomes of arthroscopic Hill-Sachs remplissage. Studies that reported on patients who underwent arthroscopic infraspinatus tenodesis concomitant with a standard Bankart repair were included if they had relevant clinical outcomes and associated complications. The frequency-weighted mean was calculated for outcome measures that were similar across several studies.

Results: Six studies fulfilled the inclusion criteria and were included in the review. The studies included 167 patients (mean age, 27.5 years) with a mean follow-up of 26.8 months (range, twelve to forty-three months). Patients had a frequency-weighted mean adjusted Rowe score of 36.1 preoperatively compared with 87.6 postoperatively ($p < 0.001$). In the studies with motion measurements, shoulder motion was not affected postoperatively ($p > 0.05$); mean forward elevation changed from 165.7° preoperatively to 170.3° postoperatively, and mean external rotation changed from 57.2° to 54.6°. Nine of 167 shoulders experienced an episode of recurrent glenohumeral instability (overall recurrence rate, 5.4%).

Conclusions: Postoperative clinical outcome scores were generally good to excellent following arthroscopic remplissage. No studies indicated a significant loss of shoulder motion following the procedure. The failure rate following Hill-Sachs remplissage compared favorably with previously published rates for patients without clinically important Hill-Sachs lesions who underwent arthroscopic Bankart repair alone. The overall complication rate across the studies was low, further supporting the use of this technique along with Bankart repair in the treatment of glenohumeral instability with a concurrent osseous defect of the humeral head.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Peer Review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Hill-Sachs lesions were first described in 1940 as the impression left by dense cortical glenoid bone on the softer cancellous bone of the posterosuperior humeral head during an anterior glenohumeral dislocation[1]. These defects are an important cause of recurrent glenohumeral instability[2-8]. To help identify lesions that are important causes of instability, both Palmer and Widen[9] and Burkhart and De Beer[2] described the "engaging" Hill-Sachs lesion, which refers to one that engages the rim of the glenoid when the shoulder is physiologically abducted and externally rotated[2]. Engaging Hill-Sachs lesions lead to recurrent instability[2,10] and a high rate of failure when treated with arthroscopic Bankart repair alone[2,11-16].

Several procedures to address humeral head defects have been proposed, including humeral head osteotomy, anterior

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

TABLE I Demographic and Operative Information*

Study	N	Mean Age *(yr)*	Male/Female *(no.)*	Dominant, Y/N *(no.)*	Mean No. of Prior Dislocations	Previous Surgery *(no.)*	Mean Follow-up (Range) *(mo)*
Boileau[34]	47	29	42/5	30/17	4	9	24 (12-43)
Franceschi[35]	25	26.3	19/6	22/3	NR	0	24.8 (SD, ±1.1)
Haviv[32]	11	25.5	11/0	NR	NR	NR	30 (24-35)
Nourissat[33]	15	24	10/5	NR	NR	NR	27 (min., 24)
Park[30]	20	27.3	15/5	9/11	NR	2	29.2 (24.3-37.7)
Zhu[31]	49	28.4	42/7	32/17	19.9	0	29 (24-35)
Total	167	27.5	139/28	93/48	—	11	26.8

*NR = not reported, and SD = standard deviation.

capsular plication, osteochondral allograft, humeroplasty, and limited resurfacing arthroplasty[17-24]. Although good clinical results may be achieved, these procedures are generally performed via an open approach and are associated with complications, including implant malfunction, nonunion, and glenohumeral arthritis[19,25-27]. Recently, Wolf and Pollack described an arthroscopic procedure known as Hill-Sachs remplissage (French: "to fill in"), which involves advancing the infraspinatus tendon and posterior capsule to the osseous surface of the Hill-Sachs lesion with suture anchors[28]. Koo et al. described a modification of this technique in which the sutures are tied over the infraspinatus tendon rather than over the muscle[29]. The aims of the remplissage technique are twofold: (1) infraspinatus tenodesis to serve as a checkrein against anterior translation of the humeral head, and (2) conversion of an intra-articular lesion to an extra-articular one. Several advantages of the remplissage technique have been cited: the arthroscopic approach, short recovery time, and avoidance of the complications associated with bone-grafting. The main cited disadvantage is the theoretical loss of external rotation resulting from the nonanatomic tethering of the infraspinatus tendon. There is, however, a relative paucity of peer-reviewed literature available to evaluate these claims.

The purpose of the present review was to systematically examine the outcomes of the arthroscopic Hill-Sachs remplissage procedure for the treatment of anterior glenohumeral instability in shoulders with a humeral head defect. We sought to answer four questions: (1) What are the inclusion and exclusion criteria commonly used to determine which patients are eligible for arthroscopic Hill-Sachs remplissage? (2) What are the expected functional outcomes following this procedure? (3) What is the instability recurrence rate after Hill-Sachs remplissage for the treatment of anterior glenohumeral instability? (4) What are the nature and frequency of complications associated with this procedure?

Our hypothesis was that arthroscopic Hill-Sachs remplissage is performed primarily in the presence of a large or engaging Hill-Sachs lesion, is not associated with significant loss of shoulder motion or poor functional outcome scores, and results in a low rate of recurrent glenohumeral instability within the first postoperative year and minimal complications.

Materials and Methods

We searched the MEDLINE, Scopus, and Embase databases from January 2000 to November 2012. Articles were identified by means of an electronic search for keyword terms and their various combinations (see Appendix). All search results and abstracts were reviewed and were included if (1) the surgical procedure under study consisted of arthroscopic Bankart repair with or without SLAP (superior labrum anterior and posterior) repair in addition to infraspinatus tenodesis to fill a humeral head defect, (2) the patients being treated had a large and/or engaging Hill-Sachs lesion, and (3) at least one relevant functional outcome such as shoulder motion, instability recurrence rate, pain, patient satisfaction, or complications was included. Articles were included if they were in English, had a minimum of twelve months of patient follow-up, and represented Level-IV evidence or higher. We excluded studies in which a concomitant procedure was performed in addition to the Bankart repair and infraspinatus tenodesis. We also excluded review, technique, or biomechanical articles that did not report patient-specific data.

All institutional and author information was concealed to minimize reviewer bias. The independent blinded reviewers reviewed each article for all outcome measures of interest, including demographic information, shoulder motion, shoulder-specific outcome measures, and recurrence and complication rates. Articles that included patients treated with multiple surgical techniques were included only if the data pertaining to the patients undergoing the surgical procedure of interest could be isolated and extracted.

The combined MEDLINE, Scopus, and Embase database searches performed with the use of the search terms listed in the Appendix yielded 789 unique articles. Twenty of these were considered relevant, and the full text of each was studied in detail to determine eligibility. Three of the twenty articles were excluded because they could not be retrieved in English. Nine articles were excluded because they were either technique or biomechanical studies that did not include patient-specific outcomes. One article was excluded because patients underwent a concomitant Latarjet or Putti-Platt Latarjet procedure in addition to arthroscopic Bankart repair and remplissage. One article was excluded because not all patients had a minimum of twelve months of follow-up. The remaining six articles were analyzed in this systematic review[30-35] (Fig. 1). The references of these articles were also searched manually for any additional articles of potential interest, which were screened using the same process as in the original search; no additional articles matching the inclusion criteria were identified.

All six of the analyzed studies included patients who underwent arthroscopic Hill-Sachs remplissage in addition to arthroscopic Bankart repair. Two of the studies also included an operative control group that underwent arthroscopic Bankart repair alone[33,35]. Both of those studies provided separate data for the two groups, and we were able to isolate the data pertaining only to the patients who underwent arthroscopic Bankart repair in addition to arthroscopic Hill-Sachs remplissage.

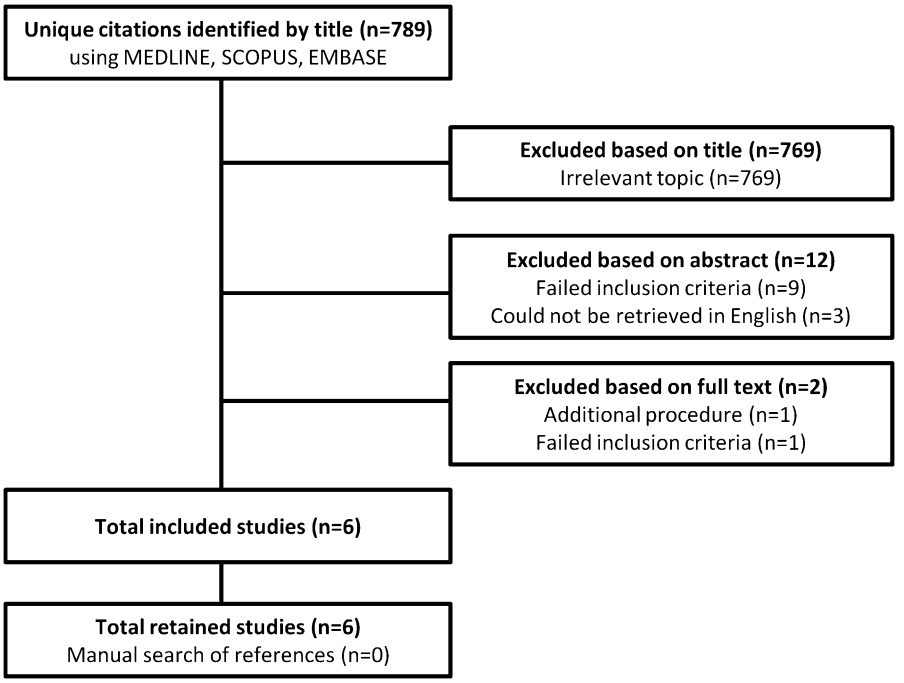

Fig. 1
Flowchart for the literature search.

For studies that used similar outcome measures, the results were pooled to generate a summary outcome, the frequency-weighted mean (calculated by weighting the mean value for each study by the number of patients in that study). If both preoperative and postoperative values for the outcome were available, the frequency-weighted means and standard deviations were used to calculate a p value for the change; a value of $p = 0.05$ was considered significant.

Source of Funding
No external funding was used for this study.

Results

The level of evidence of the six studies that met the inclusion and exclusion criteria and were included in this review was reported as IV in four studies[30-32,34], III in one[35], and II in one[33] (see Appendix). Four of the studies were retrospective series, although it was not stated whether these represented consecutively selected patients[30,31,34,35]; the other two studies were prospective, not blinded, and not randomized[32,33]. Two studies included a comparison group of patients treated without arthroscopic Hill-Sachs remplissage[33,35], and all studies evaluated a uniform cohort of patients who underwent arthroscopic Hill-Sachs remplissage in addition to Bankart repair for a large and/or engaging Hill-Sachs lesion. Indications for arthroscopic remplissage included an engaging Hill-Sachs lesion found during arthroscopy in four of the studies[31,32,34,35], the size of the humeral head defect in one study[30], and the Instability Severity Index Score (ISIS)[36] in conjunction with the presence of a Hill-Sachs lesion in one study[33]. Five studies excluded patients with substantial glenoid bone loss[31-35], with two of these studies defining a substantial glenoid lesion as <25% of the entire glenoid[31,35] and the other three not providing a size cutoff[32-34]. The similar inclusion and exclusion criteria indicated that the included studies represented a nearly homogenous patient population suitable for systematic review.

Demographics
The six studies contained a total of 167 patients (range, eleven to forty-nine per study)[30-35] (Table I). The mean patient age was 27.5 years (range, fourteen to seventy-five years); 139 (83%) of the patients were male and twenty-eight (17%) were female. Four studies indicated whether or not the operatively treated extremity was the dominant extremity, with ninety-three (66%) of the procedures performed on the dominant side and forty-eight (34%) on the nondominant side[30,31,34,35]. Four studies included data on the number of patients who had undergone previous stabilization surgery (total, eleven of 141; 7.8%)[30,31,34,35]. The eleven failed previous procedures consisted of six open Bristow-Latarjet procedures, one open Bankart procedure, two arthroscopic Bankart repair procedures, and two procedures that were not specified in the study[30,34]. Two studies indicated the amount of preoperative glenoid bone loss with use of the Sugaya Index, which averaged 14.9% (range, 10.5% to 23.6%)[31,35]. Only two studies indicated the Hill-Sachs lesion size, reported as a mean Hill-Sachs depth index (D/R) of 30.6% (range, 11.6% to 73.5%) in one study[35] and as a mean loss of 17.3% (range, 7.7% to 26.8%) of the humeral head diameter in the other study[31].

Surgical Technique
In five of the six studies, the arthroscopic Hill-Sachs remplissage procedure was exactly the same as the original procedure described by Purchase et al.[37], and in the sixth study[35] the procedure was slightly modified, involving use of the double-pulley

TABLE II Range of Motion Outcomes

Study	Preop./Postop. Motion*					
	FE *(deg)*	ER *(deg)*	ER_{abd} *(deg)*	ER strength *(kg)*	IR *(deg or vertebrae)*	IR_{abd} *(deg)*
Boileau[34]	NR/175	NR/55	NR/76	NR	NR/9.3	NR/64
Franceschi[35]	170.9/168.9	60.6/56.0	NR	NR	T6/T6	NR
Haviv[32]	NR/''normal''†	NR/83%†‡	NR	NR	NR/''normal''†	NR
Nourissat[33]	NR/−14.0†	NR/−13.7†	NR/−18.5†	NR	−2 vertebrae†	NR
Park[30]	NR	NR	NR	NR	NR	NR
Zhu[31]	162.9/170.9	56/54.1	NR	8.6/8.7	T7/T7	NR

*FE = forward elevation, ER = external rotation, abd = with arm in abduction, IR = internal rotation, and NR = not reported. †Compared with the contralateral side. ‡Percentage of arc of motion of the contralateral side.

technique described by Koo et al.[29]. All studies used either one or two suture anchors, depending on the size of the humeral head defect. A standard arthroscopic Bankart repair was performed in addition to the Hill-Sachs remplissage in all cases[30-35]. Two studies indicated that, in patients with an identified SLAP lesion at the time of surgery, SLAP repair was performed in addition to the arthroscopic Bankart repair and Hill-Sachs remplissage[31,35].

Outcomes

Patients were followed for a mean of 26.8 months (range, twelve to forty-three months). Preoperative and postoperative Rowe scores were reported in three studies (n = 85)[31,32,35]; the mean adjusted Rowe score was 36.1 preoperatively compared with 87.6 postoperatively ($p < 0.001$)[31,32,35]. The percentage of patients with a good-to-excellent postoperative Walch-Duplay score was reported in two studies; a total of fifty-five (89%) of sixty-two patients had such a score[33,34]. Two studies (n = 96) surveyed patients regarding their return to sporting activities after surgery; a total of seventy-seven (80%) of ninety-six patients reported a successful return to sports[31,34]. Other shoulder-specific outcome measures are summarized in the Appendix.

The authors of two studies (n = 74) reported preoperative and postoperative forward elevation and external rotation with the arm at the side[31,35]. Forward elevation improved from a frequency-weighted mean of 165.7° preoperatively to 170.3° postoperatively and mean external rotation with the arm at the side declined from 57.2° to 54.6°[31,35]; these changes were not significant ($p > 0.05$). The six studies were inconsistent with regard to reporting of external rotation in shoulder abduction and internal rotation. Shoulder motion outcome measures are summarized in Table II.

Imaging

Postoperative imaging following the arthroscopic Hill-Sachs remplissage was performed in four studies (n = 92), with a total of thirty-eight patients undergoing CT (computed tomography) arthrography and fifty-four patients undergoing MRI (magnetic resonance imaging) at one to two years of follow-up[31,33-35]. All patients had evidence of healing or filling of the humeral head defect[31,33-35]. The authors of only one of the studies attempted to quantify the percentage of the defect that was filled by tendon; they found that thirty-one (74%) of forty-two patients had "filling" of >75% of the defect and only two (5%) had "filling" of <50%[34].

Recurrence Rate and Complications

The authors of all six studies reported on the recurrence rate of glenohumeral instability. At a mean follow-up of 26.8 months following arthroscopic Hill-Sachs remplissage, nine of 167 shoulders had experienced an episode of instability, representing a recurrence rate of 5.4%[30-35]. Of these nine patients with recurrent glenohumeral instability, two had a traumatic dislocation, two had an atraumatic dislocation, one had a dislocation after a seizure, three had an episode of subluxation, and one had a positive apprehension test (see Appendix). One of the nine patients underwent an arthroscopic Latarjet procedure with no further recurrence of symptoms[33], four did not elect or did not require further surgical intervention[30,34], and the treatment decision was not reported for the remaining four patients[31]. Aside from recurrence of glenohumeral instability, only one (0.6%) of the 167 patients had a complication following arthroscopic Hill-Sachs remplissage[30-35] (Table III). That patient developed tenosynovitis of the long head of the biceps

TABLE III Complications

Study	N	Complications*
Boileau[34]	47	1, tenosynovitis of long head of biceps
Franceschi[35]	25	NR
Haviv[32]	11	0
Nourissat[33]	15	0
Park[30]	20	0
Zhu[31]	49	NR
Total	167	1

*NR = not reported.

at one year following surgery and was treated successfully with arthroscopic biceps tenodesis; full healing of the posterior capsulotenodesis was noted within the humeral head defect on postoperative CT arthrography[34].

Discussion

Engaging Hill-Sachs lesions have long been associated with anterior shoulder dislocation, but the extent of their contribution to recurrent instability was not fully appreciated until the work of Burkhart and De Beer[2]. In their report of the outcome of arthroscopic Bankart repair, recurrent instability occurred after 10.8% (twenty-one) of 194 procedures, but those with a large osseous defect had a failure rate of 67% compared with 4% in those without a large defect[2]. Furthermore, contact athletes with a large osseous defect had an 89% failure rate[2]. Investigators have since continued to demonstrate the contribution of large, engaging Hill-Sachs lesions to recurrent glenohumeral instability[7,38,39].

The Hill-Sachs remplissage procedure is an arthroscopic technique that allows for the filling of a humeral head defect concomitant with Bankart repair. In this systematic review, the inclusion criteria for Hill-Sachs remplissage were similar among many of the studies. Although all authors required evidence of a Hill-Sachs lesion on preoperative imaging, the ultimate decision to perform the remplissage procedure was usually based on engagement of the humeral head defect on the anterior aspect of the glenoid during dynamic arthroscopic assessment[31,32,34,35]. There was nearly universal agreement that patients must be without "substantial" glenoid bone loss, most frequently cited as <25% osseous deficiency of the glenoid[31,35], for the remplissage procedure to be considered. This differs from the previous suggestion by Purchase et al. that remplissage is an effective arthroscopic augment to Latarjet or similar bone-grafting procedures in cases in which glenoid bone loss is present in addition to a Hill-Sachs lesion[37]. Overall, five of the six studies indicated use of remplissage in addition to arthroscopic Bankart repair to treat recurrent instability specifically in those patients who had an engaging Hill-Sachs lesion identified during arthroscopic evaluation and did not have substantial glenoid bone loss (see Appendix). Unfortunately, only two studies indicated the amount of glenoid bone loss, and only these two studies indicated the amount of humeral bone loss[31,35]. We are therefore unable to draw any specific conclusions regarding the exact amount of humeral or glenoid bone loss in this study population. Researchers performing future studies should attempt to quantify these amounts to better understand the indications for this procedure[2,3].

The majority of patients who underwent arthroscopic Hill-Sachs remplissage were young (frequency-weighted mean age, 27.5 years), were male (83%), and underwent surgery on the dominant extremity (66%)[30-35]. No attempt to demonstrate a difference in outcome on the basis of age, sex, or extremity dominance was made in any of the studies. None of the eleven patients for whom the arthroscopic Hill-Sachs remplissage represented a revision stabilization procedure had recurrent instability at a minimum of one year of follow-up.

In general, our review demonstrates that arthroscopic Hill-Sachs remplissage was associated with good to excellent shoulder-specific outcome scores. The frequency-weighted mean postoperative Rowe score in three studies including eighty-five patients was 87.6, classified as "excellent."[40] Because of the variability in outcome scores used, we were unable to calculate frequency-weighted mean outcome values for the majority of the shoulder outcome measures used. We are therefore limited in our ability to predict the subjective outcome measures that can be expected following Hill-Sachs remplissage. However, arthroscopic Hill-Sachs remplissage was associated with good-to-excellent shoulder-specific outcome measures in all six of the studies that we identified (see Appendix). More uniform use of validated outcome measures in future studies would help to elucidate the functional outcomes associated with this procedure[41].

Hill-Sachs remplissage is a nonanatomic surgical technique, and for this reason many authors have cited concerns regarding a theoretical adverse effect on postoperative shoulder motion, particularly loss of external rotation. Deutsch and Kroll reported a decrease in external rotation from 70° to 45° following remplissage in one patient; arthroscopic release of the infraspinatus tenodesis resulted in an improvement in external rotation to 60°[42]. None of the six studies that we reviewed documented a significant loss of shoulder motion[30-35] (Table II), although this has been reported in prior studies. Several of the studies did reveal a deficit compared with the contralateral shoulder[32-34]. However, external rotation deficits are well documented following arthroscopic Bankart repair alone[43-49] and have been reported to be as large as 13° to 21° following Latarjet or other bone-grafting procedures[7,50,51]. It is important that all future studies report standardized shoulder motion measures for the operatively treated shoulder to facilitate comparison among studies.

All six studies indicated the rate of glenohumeral instability recurrence at a mean of two years postoperatively. Overall, the recurrence rate was 5.4% in the 167 patients who underwent arthroscopic remplissage in addition to a standard Bankart repair[30-35]. Prior studies have indicated failure rates between 4% and 18% following arthroscopic Bankart repair[13,43-46,48,49,52-55]. Given that Hill-Sachs lesions increase the rate of recurrence[2,12] and that the six studies in the present review included only patients with clinically important Hill-Sachs lesions, we hypothesize that the recurrence rate following arthroscopic Bankart repair alone would have been higher in this population. Therefore, the 5.4% pooled recurrence rate with the addition of Hill-Sachs remplissage compared favorably with the expected rate for arthroscopic Bankart repair alone in this particular study population. Although complications following arthroscopic remplissage have been noted in a single case report[42], we found a reported complication rate of only 0.6% (one of 167) in the patients included in the six studies.

Our review has limitations. Any systematic literature review is limited by the weakness of each individual study, which included retrospective study design, a small number of

patients, short-term follow-up, and a high variability of patient outcome measures used. Because of the variation in reported outcome measures, we were unable to statistically aggregate many of the measures of interest. In addition, most of the reports were descriptive in nature and therefore did not control for bias or confounding, a weakness that is therefore also reflected in our review. Our review design precluded drawing any definitive conclusions regarding the subjective or objective outcomes associated with the procedure under study. It is possible that we missed additional studies that would have satisfied our inclusion criteria. Given these limitations, endorsement of this procedure on the basis of reproducible, statistically verified outcome measures was not possible.

In conclusion, a systematic review of the literature revealed that arthroscopic Hill-Sachs remplissage for the treatment of osseous defects of the humeral head in the presence of glenohumeral instability was associated with a low rate of recurrent instability, good clinical and functional outcome scores, and a low rate of complications. Loss of shoulder motion, particularly external rotation, was not widely reported. The definitive indication for this procedure remains controversial, however, particularly with respect to the size and location of humeral head defects.

Appendix

eA Tables summarizing the search terms used as well as the design, inclusion and exclusion criteria, clinical outcomes, and recurrence rates for each included study are available with the online version of this article as a data supplement at jbjs.org. ■

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