



## Lesions of the biceps pulley: a prospective study and classification update



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**Hypothesis:** The purpose of the study was to investigate which anatomic structures are affected in a series of patients with pulley lesions and whether all lesions can be classified according to the Habermeyer classification.

**Methods:** One hundred consecutive patients with pulley lesions were prospectively studied. During arthroscopy, lesions of the superior glenohumeral ligament (SGHL), medial coracohumeral ligament (MCHL) and/or lateral coracohumeral ligament (LCHL), adjacent rotator cuff, and biceps (long head of the biceps) were recorded. All lesions were then classified according to the Habermeyer classification. The  $\chi^2$  test was used for statistical analysis.

**Results:** There were 3 lesions in group 1, 20 in group 2, 6 in group 3, and 35 in group 4 according to the Habermeyer classification. Thirty-six lesions were not classifiable because of an intact SGHL. A lateral pulley sling (LCHL) lesion was found in 95% of the patients, and a medial pulley sling (MCHL-SGHL) lesion was noted 64%. An isolated lesion of the MCHL and/or SGHL was present in 5%, and an isolated lesion of the LCHL was found in 36%. Combined medial-lateral sling lesions were correlated with complete subscapularis tears and biceps fraying.

**Conclusion:** The lateral pulley sling is more often affected than the medial sling. The SGHL is not always affected, and isolated lesions of the medial sling are rare. Lesions of both slings correlated with complete subscapularis tears and fraying of the long head of the biceps. An updated classification of direct pulley lesions is proposed: type 1, lesion of the medial pulley (MCHL and/or SGHL); type 2, lesion of the lateral pulley (LCHL); and type 3, lesion of the medial and lateral pulley slings. Concomitant lesions of the indirect pulley stabilizers can be mentioned additionally according to the well-known classifications.

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The biceps reflection pulley (BRP) is a soft tissue sling consisting of fibers of the superior glenohumeral ligament (SGHL), coracohumeral ligament (CHL), and supraspinatus (SSP) and subscapularis (SSC) tendon. It acts to stabilize the tendon course of the long head of the biceps (LHB) before it enters the bony bicipital groove<sup>10,23</sup> (Fig. 1). Acute trauma, repetitive microtrauma, and degeneration of the involved soft tissues can result in a lesion of the biceps pulley.<sup>1,5,8</sup> The prevalence of BRP lesions during shoulder arthroscopy is >7%, and such lesions are a considerable source of morbidity.<sup>1,15</sup> Injuries to the BRP are often found in patients with

anterior shoulder pain and are frequently associated with rotator cuff tears, superior labrum anterior-posterior lesions, biceps instability, and biceps tears.<sup>3-6,21</sup> Furthermore, BRP lesions have been reported to be associated with internal anterosuperior impingement.<sup>12</sup> Several studies have published different classification systems for LHB dislocation or subluxation and correlated these pathologies with pulley lesions.<sup>3,12,20,21</sup> Depending on the current classification systems, the “essential” lesion is either an SGHL lesion with or without anterosuperior rotator cuff tears (SSP and/or infraspinatus) or a CHL tear (either medial or lateral head) accompanied by anterosuperior rotator cuff tears.<sup>3,12</sup> Today, the classification published by Habermeyer et al<sup>12</sup> is widely used to describe these lesions and refers exclusively to lesions of the SGHL either in isolation or with additional rotator cuff lesions.

The main goal of this study was to investigate biceps pulley lesions prospectively and to categorize the affected anatomic

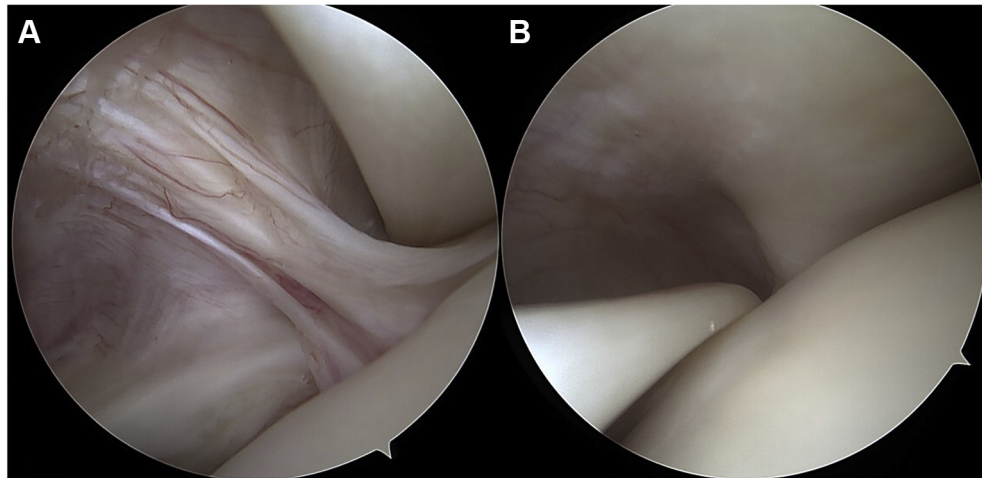
Institutional Review Board approval was obtained from ATOS Klinik Heidelberg (no. 01/17).

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**Figure 1** The biceps reflection pulley is a soft tissue sling consisting of fibers of the superior glenohumeral ligament, coracohumeral ligament, and adjacent rotator cuff fibers (indirect pulley stabilizers). Arthroscopic photographs of a right shoulder show the medial pulley sling, which consists of the superior glenohumeral ligament and medial coracohumeral ligament (A), and the lateral pulley sling, which consists of the lateral part of the coracohumeral ligament (B).

structures to analyze whether all lesions can be classified using the Habermeyer classification system. The secondary goals were to investigate the number and type of concomitant pathologies and to evaluate whether there are specific concomitant lesions with respect to the different pulley lesions.

## Materials and methods

### Study design

This was a prospective study of 100 consecutive patients with anterior shoulder pain and arthroscopically confirmed pulley lesions who underwent shoulder arthroscopy between January and July 2018 at a single specialized shoulder center. All patients gave their informed consent to participate in the study.

The exclusion criteria were patients without BRP lesions; patients with a completely torn LHB tendon, massive rotator cuff tears, or advanced arthritic changes of the glenohumeral joint; and patients younger than 18 years. All pathologies were thoroughly documented by use of an intraoperatively filled out questionnaire and additional video documentation. All surgical procedures were performed by 3 orthopedic surgeons specialized in shoulder surgery. To categorize the present BRP lesions, we documented the integrity of the SGHL and CHL (medial head [ie, medial coracohumeral ligament (MCHL)] and lateral head [ie, lateral coracohumeral ligament (LCHL)])<sup>3</sup> and the following pathologies: complete and partial lesions of the SSC tendon, complete and partial lesions of the SSP tendon, lesions of the LHB tendon (fraying or partial rupture), tendinitis of the intra-articular portion, and tendinitis of the intertubercular groove portion.<sup>7,11</sup>

The 3 surgeons reviewed all lesions for consensus before classification. Finally, the lesions were categorized according to the Habermeyer classification system: isolated lesion of the SGHL (group 1), lesion of the SGHL along with an SSP tear (group 2) or SSC tear (group 3), or lesion of the SGHL combined with an SSP and SSC tendon tear (group 4).

### Statistics

Descriptive statistics, that is, means (standard deviations) and frequencies, were used to evaluate the distribution of continuous

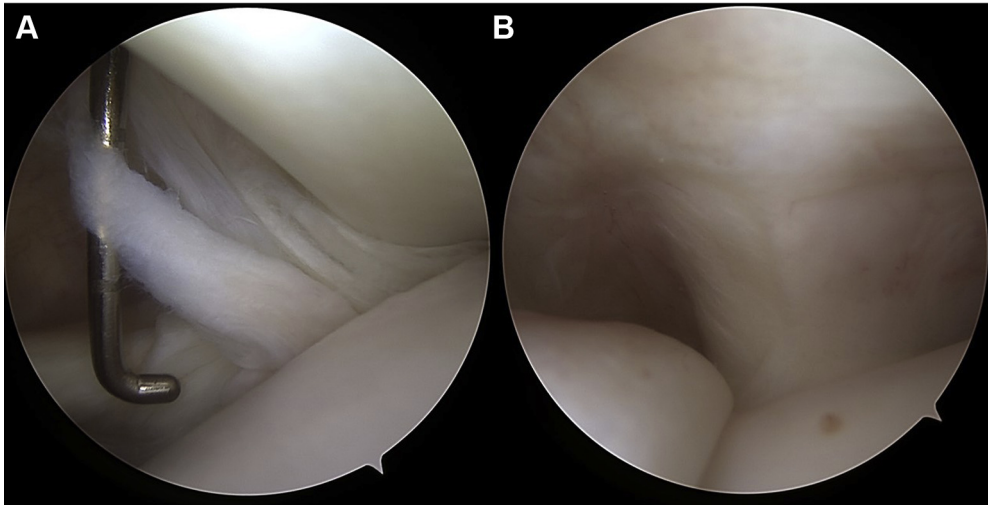
data (age) and nominal data (types of pulley lesions and concomitant lesions), respectively. For each type in the updated classification according to the injured structures of the BRP, the frequencies of partial and complete SSP and SSC lesions, as well as LHB pathology (tendinitis of the intra-articular portion, tendinitis of the intertubercular groove portion, and fraying or partial rupture), were calculated. The Pearson  $\chi^2$  test was used to investigate differences in the frequency of lesions of the rotator cuff and of the LHB with the 3 types of pulley lesions (according to the injured structures involved) in the updated classification. The level of significance was set a priori at  $\alpha = .05$ . Statistical analysis was performed with the SPSS statistical software package (version 13.0; IBM, Armonk, NY, USA).

## Results

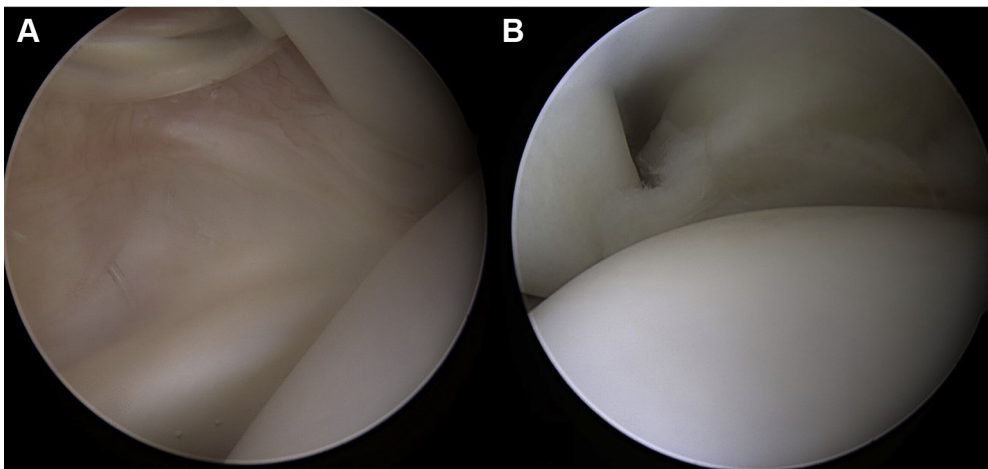
During the study period, a total of 708 shoulder arthroscopies were performed. Only patients with anterior shoulder pain who were willing to participate in the study and did not meet any of the exclusion criteria were enrolled in the study. A total of 100 consecutive patients were evaluated and included in the study. The mean age of the patients was 59.1 years. The sex distribution was 66 male and 34 female patients. Arthroscopic evaluation of the pulley lesions revealed 3 lesions in group 1, 20 in group 2, and 6 in group 3, and 35 in group 4. However, 36 lesions (36%) were not classifiable according to the Habermeyer classification because the SGHL fibers were not affected. These lesions could all be properly described and classified with the updated classification.

In terms of the injured structures, a lesion of the direct lateral pulley sling (LCHL) was found in 95% of the cases and a lesion of the direct medial pulley sling (MCHL and/or SGHL) was present in 64%. An isolated lesion of the direct medial pulley sling was observed in only 5% of the patients (Fig. 2), whereas 36% of the patients showed an isolated lesion of the direct lateral pulley sling (Fig. 3). The medial and lateral pulley slings were affected in 59% of the patients (Fig. 4).

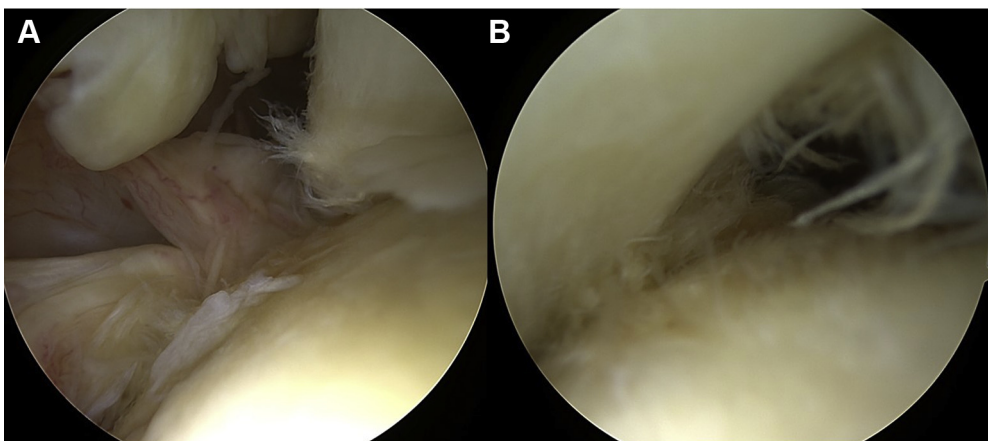
Regarding concomitant pathologies of the LHB tendon (tendinitis of the intra-articular portion, tendinitis of the intertubercular groove portion, and fraying or partial rupture), the relative frequencies with respect to the injured structures of the pulley system as described earlier are shown in Table 1. Combined lesions of the



**Figure 2** Arthroscopic photographs of a right shoulder showing a type 1 lesion according to the updated classification, that is, an isolated lesion of the direct medial pulley sling. (A) Partial tear of medial pulley sling (medial coracohumeral ligament and/or superior glenohumeral ligament). (B) Intact lateral pulley sling (lateral coracohumeral ligament).



**Figure 3** Arthroscopic photographs of a right shoulder showing a type 2 lesion according to the updated classification, that is, an isolated lesion of the direct lateral pulley sling. (A) Intact medial pulley. (B) Torn lateral pulley sling.



**Figure 4 (A, B)** Arthroscopic photographs of a right shoulder showing a type 3 lesion according to the updated classification with completely torn medial and lateral pulley slings. Fraying (partial rupture) of the long head of the biceps tendon is also noted.

**Table I**

Relative frequencies of concomitant pathology of long head of biceps tendon for each type of pulley lesion according to updated classification

Pulley lesion	Long head of biceps tendon lesion		
	Tendinitis of intra-articular portion	Tendinitis of intertubercular groove portion	Fraying or partial rupture
Medial pulley sling (MCHL + SGHL)	1	2	1
Lateral pulley sling (LCHL)	8	30	9
Combined medial and lateral pulley sling	21	40	42
Total	30	72	52

MCHL, medial coracohumeral ligament; SGHL, superior glenohumeral ligament; LCHL, lateral coracohumeral ligament.

medial and lateral pulley sling showed the highest frequencies for all recorded co-pathologies of the biceps tendon. For the detection of differences in the frequencies of concomitant LHB pathology, the  $\chi^2$  test was performed only for isolated lateral pulley sling lesions and combined lesions of the medial and lateral pulley sling because there were only 5 cases with isolated medial pulley sling lesions. The Pearson  $\chi^2$  test showed a difference in the frequencies of LHB fraying or partial rupture between combined medial and lateral pulley sling lesions (71%) and isolated lateral pulley sling lesions (25%) ( $P < .001$ ), showing that combined lesions of the medial and lateral pulley sling are related to a higher frequency of fraying or partial tearing of the LHB compared with isolated lateral pulley sling lesions. No statistically significant differences were noted for the frequencies of the other LHB lesions (tendinitis of the intra-articular portion and tendinitis of the intertubercular groove portion), although there was a tendency for a higher frequency of tendinitis of the intertubercular groove portion with isolated lateral pulley sling lesions ( $P = .095$ ).

Regarding concomitant lesions of the indirect stabilizers of the pulley system, 40 articular-sided partial tears and 48 complete tears of the SSP tendon, as well as 28 partial and 18 complete tears of the SSC tendon, were recorded. The relative frequencies of these concomitant rotator cuff lesions for each type of pulley lesion (ie, medial pulley sling, lateral pulley sling, or both) are depicted in Table II.

For the detection of differences in the frequencies of concomitant rotator cuff lesions, the  $\chi^2$  test was again performed for only isolated lateral pulley sling lesions and combined medial and lateral pulley sling lesions because of the low number of cases ( $n = 5$ ) with isolated medial pulley sling lesions. The Pearson  $\chi^2$  test showed a difference in the frequencies of complete SSC tears between type 3 (30%) and type 2 (0%) pulley lesions ( $P < .001$ ). No differences were noted for the frequencies of the other rotator cuff lesions (complete and partial SSP tears and partial SSC tears). According to these results, combined medial and lateral pulley sling lesions were related more frequently to complete SSC tears compared with isolated lateral pulley sling lesions.

## Discussion

The first aim of this study was to prospectively review biceps pulley lesions and to categorize the anatomic structures that are affected to investigate whether all lesions can be described according to the classification system currently used. The second aim was to investigate the number and type of concomitant pathologies and test whether differences exist in the frequency of these pathologies with respect to the pulley lesions. The most important findings of the study underlined that the lateral pulley sling (LCHL) is more often affected than the medial sling (MCHL and/or SGHL) and that the SGHL is not affected in all cases of BRP lesions. The study hypothesis that not all pulley lesions would be correctly categorized according to the classification of Habermeyer et al<sup>12</sup> has been supported because in 36% of the lesions, the SGHL fibers were

**Table II**

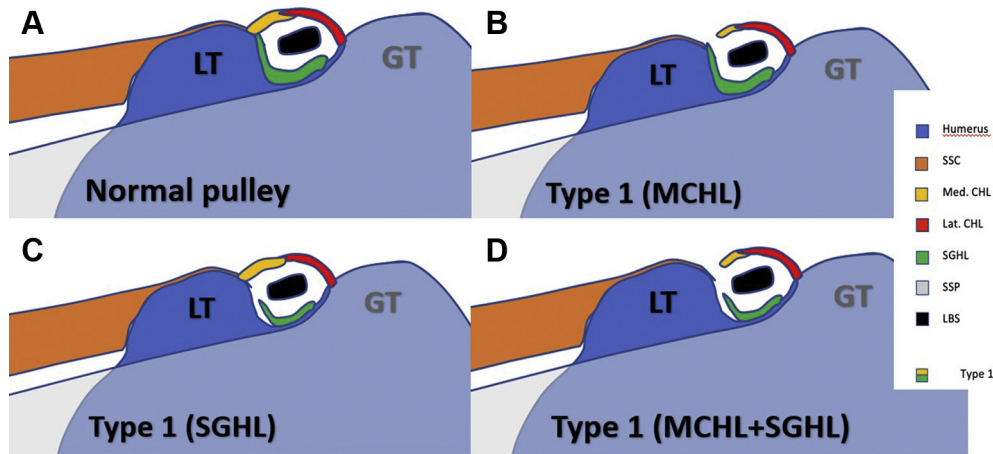
Relative frequencies of concomitant lesions of adjacent rotator cuff fibers for each type of pulley lesion according to updated classification

Pulley lesion	Rotator cuff lesion				Total
	pSSP	cSSP	pSSC	cSSC	
Medial pulley sling (MCHL + SGHL)	2	0	1	0	3
Lateral pulley sling (LCHL)	18	15	9	0	42
Combined medial and lateral pulley sling	20	33	18	18	89
Total	40	48	28	18	134

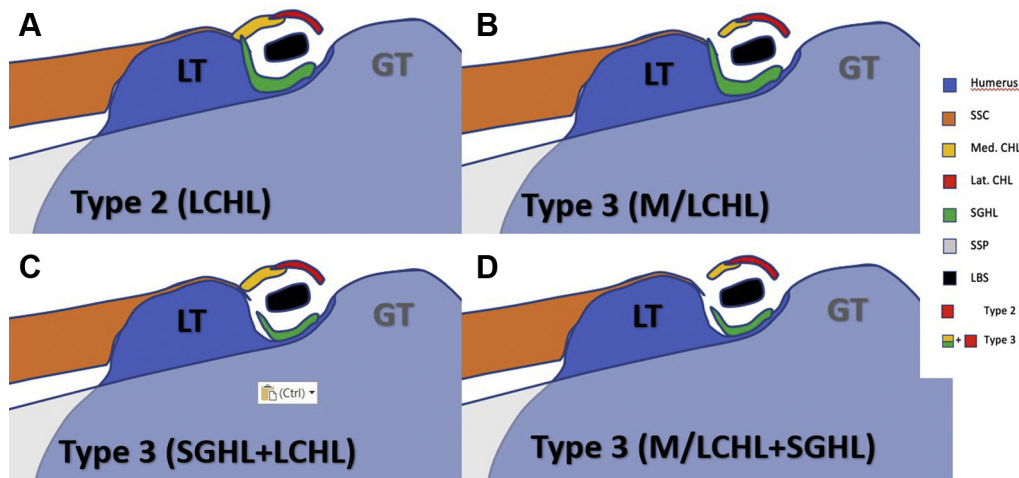
pSSP, partial tear of supraspinatus tendon; cSSP, complete tear of supraspinatus tendon; pSSC, partial tear of subscapularis tendon; cSSC, complete tear of subscapularis tendon; MCHL, medial coracohumeral ligament; SGHL, superior glenohumeral ligament; LCHL, lateral coracohumeral ligament.

not affected. Thus, an updated and simplified classification system has been proposed allowing for categorization of all documented pulley lesions: type 1, medial pulley sling (SGHL and MCHL) lesion (Fig. 2; Fig. 5, B-D); type 2, lateral pulley sling (LCHL) lesion (Fig. 3; Fig. 6, A); and type 3, medial and lateral pulley sling (SGHL and CHL) lesion (Fig. 4; Fig. 6, B-D). This updated and simple classification allows for a clear statement regarding biceps instability and its direction. Concomitant lesions of the indirect pulley stabilizers (rotator cuff fibers) can be mentioned additionally according to the existing classifications if desired. Secondary findings were that combined medial and lateral pulley sling lesions (type 3 according to the updated classification) showed a significantly higher frequency of concomitant complete SSC tears and significantly higher frequency of fraying or partial rupture of the LHB compared with isolated lateral pulley sling lesions (type 2 according to the updated classification).

In 2004, Habermeyer et al<sup>12</sup> described BRP lesions as isolated lesions of the SGHL (group 1), as lesions of the SGHL along with an articular-sided SSP tear (group 2) or SSC tear (group 3), or as a combination of all lesions (group 4). It was noted that the SGHL is the most important structure for stabilizing the LHB, and in their prospective study, these authors reported isolated lesions of the SGHL in 33% of cases.<sup>12</sup> In another study, Baumann et al<sup>1</sup> found a greater incidence for isolated lesions of the SGHL, reaching 74%. We found an incidence of only 5% for isolated medial sling pulley lesions (SGHL and/or MCHL) in our study. The different findings between the previous studies and our study might be a result of different inclusion and exclusion criteria. In particular, in their study, Baumann et al excluded cases with complete adjacent rotator cuff tears, as well as tears of more than 50%, and SLAP lesions. In our study, all patients with pulley lesions were prospectively included and the concomitant lesions were recorded as well. Although Baumann et al stated that BRP lesions might initially have caused many complete tears of the rotator cuff adjacent to the rotator interval, they excluded patients with complete tears because of the inability to retrospectively correlate the cause of complete tears in the presence of concomitant pulley lesions. In our study,



**Figure 5** Schema of normal pulley and type 1 lesions according to proposed updated classification system. (A) Normal pulley structures. (B) Type 1 medial pulley sling lesion with torn medial coracohumeral ligament (MCHL). (C) Type 1 medial pulley sling lesion with torn superior glenohumeral ligament (SGHL). (D) Type 1 medial pulley sling lesion with torn MCHL and SGHL. LT, lesser tuberosity; GT, great tuberosity; SSC, subscapularis; Med, medial; CHL, coracohumeral ligament; Lat, lateral; SSP, supraspinatus; LBS, long head of biceps tendon.



**Figure 6** Schema of type 2 and type 3 lesions according to proposed updated classification system. (A) Type 2 lateral pulley sling lesion with torn lateral coracohumeral ligament (LCHL). (B) Type 3 medial and lateral pulley sling lesion with torn medial (M) coracohumeral ligament and LCHL. (C) Type 3 medial and lateral pulley sling lesion with torn SGHL and LCHL. (D) Type 3 medial and lateral pulley sling lesion with torn medial (M) coracohumeral ligament, LCHL, and SGHL. LT, lesser tuberosity; GT, great tuberosity; SSC, subscapularis; Med, medial; CHL, coracohumeral ligament; Lat, lateral; SSP, supraspinatus; LBS, long head of biceps tendon.

the aim was to prospectively record pulley lesions regarding the injured structures of the reflection pulley system, as well as any concomitant pathology, and secondarily to detect any differences or correlation between the frequencies of these lesions. However, it should be noted that this does not necessarily imply a causative relationship.

In our study, type 3 pulley lesions according to the proposed classification were significantly related to an increased frequency of concomitant complete SSC tears as opposed to type 2 lesions. Although no relative statistical analysis was performed for type 1 (medial sling) lesions because of the small number of cases, none of the 5 patients with medial sling lesions exhibited complete SSC tears. Several authors have noted the association of medial sheath lesions with various injuries to the rotator cuff tendons and, in particular, with lesions of the intra-articular SSC tendon.<sup>2,3,12,14</sup> Habermeyer et al<sup>12</sup> concluded that a lesion of the pulley system that causes LHB instability may be related to a partial articular-side SSC tendon tear. Walch et al<sup>21</sup> mentioned that intra-articular dislocation of the LHB was related to complete tears of the SSC and of the pulley system, although they did not specifically

investigate the pulley system lesions. Several authors have shown that SGHL or CHL lesions are strongly associated with partial articular-side rotator cuff tears.<sup>13,16,17,19,22</sup> Our findings indicate, for the first time, that a lesion of both the medial and lateral pulley slings is related to complete SSC tears and fraying or partial tearing of the LHB tendon. Although this result does not necessarily imply a causative relationship, a possible explanation may be that the increased amount of instability that results from a type 3 pulley lesion (according to the updated classification) might, over time, result in a subsequent complete SSC tear and fraying or even partial tearing of the LHB. This finding is in accordance with the results of previous studies that have suggested that pulley lesions may cause instability of the LHB and finally alterations of the LHB itself.<sup>12,18</sup>

However, it should be mentioned that the reflection pulley may also be secondarily affected in the setting of rotator cuff tears.<sup>9,11,21</sup> Therefore, of course, the “which came first” question regarding pulley and rotator cuff tears cannot be answered with this study.

To complete and simplify the classification of pulley lesions, the following classification system has been proposed: type 1, medial pulley sling (SGHL and medial CHL) tear; type 2, lateral pulley sling

(lateral CHL) tear; and type 3, combined medial and lateral pulley sling (SGHL and CHL) tear. In addition, the involvement of the rotator cuff tendons may be added as an anterior, superior, or anterosuperior rotator cuff tear with a type 1, 2, or 3 pulley lesion, or the rotator cuff tear can be strictly classified according to the existing classifications for complete or partial tears if desired.

The limitations of this study include the small number of cases with the medial sling type of pulley lesion and the inability to test for the frequency of concomitant rotator cuff lesions. However, this small incidence possibly reflects the true incidence of an isolated medial sling type of lesion. Another limitation is that we did not correlate our findings and the types of the proposed classification to the direction of instability of the LHB tendon as noted intraoperatively. Future directions of study should be to confirm these observations in a further, larger clinical study. However, this is the first study to prospectively evaluate the true incidence of the involved different anatomic structures in lesions of the BRP.

## Conclusion

This prospective analysis showed that the lateral pulley sling is more often affected than the medial pulley sling, whereas the SGHL is not affected in all cases and isolated lesions of the direct medial sling are rare. For simplification but exact classification of pulley lesions, we propose the following update for direct pulley sling lesions: type 1, lesion of the medial pulley sling (MCHL and/or SGHL); type 2, lesion of the lateral pulley sling (LCHL); and type 3, lesion of the medial and lateral pulley slings. Concomitant lesions of the indirect pulley stabilizers (rotator cuff fibers) can be mentioned additionally according to the well-known classifications if desired. In this study, type 3 lesions according to the updated classification showed significantly higher frequencies of concomitant complete SSC tears and fraying or partial rupture of the LHB than type 2 lesions.

## Disclaimer

Frank Martetschläger is a consultant for Arthrex.

Mark Tauber is a consultant for Arthrex and Exactech.

Peter Habermeyer is a consultant for and receives royalties from Arthrex.

The other author, her immediate family, and any research foundations with which she is affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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