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ORIGINAL ARTICLE

Correlation between preoperative clinical examination and intraoperatively found subscapularis tendon tear

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Abstract

Purpose Analyze the diagnostic value for subscapularis (SSC) tendon tears, their correlation between pain and strength on clinical tests, and compare them with intraoperative arthroscopic findings to prove their diagnostic value.

Methods 110 consecutive patients undergoing arthroscopic rotator cuff repair were reviewed and allocated to isolated SSC ($n=39$) and combined anterosuperior tendon tear ($n=71$) groups and analyzed. Preoperative clinical testing included belly press (BPT), bear hug (BHT), lift-off (LOT), palm-up (PUT), and Jobe test (JT). All tests were performed in two categories: pain (in 4 categories: 0, 5, 10, and 15) and strength (from 0 to 5). The tendon tears were intraoperatively reviewed and classified.

Results Mean age was 59 years (SD 10). The sensitivity of the BHT was 88.2% and 74.5% for BPT, while specificity was only 41.9% for BHT and 45% for BPT. Sensitivity of JT was 90.5% and 87.5% for PUT, while specificity was only 41% for JT and 28.2% for PUT. A low positive correlation for an intraoperative SSC lesion and the strength of BPT (Spearman rank correlation -0.425; p value <0.0001) and the strength of BHT (-0.362; p value $=0.001$) could be found. With linear regression analysis estimated by ordinary least squares, a correlation between BPT strength and surgical grade of SSC lesion (-0.528; 95% CI, -0.923 to -0.133; $p$value <0.01) was found.

Conclusion The BHT showed a higher sensitivity for a SSC lesion, while the BPT had a higher correlation between preoperative testing, most notably internal rotation strength, and intraoperative surgical grade of the SSC tendon lesion.

Level of evidence Level II, Prospective cohort study for Diagnostic tests.

Keywords Subscapularis tendon tear · Anterosuperior tendon tears · Supraspinatus tendon tear · Arthroscopic rotator cuff repair

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Abbreviations

BHT	Bear hug test
BPT	Belly press test
JT	Jobe test
MMT	Manual muscle testing
PUT	Palm-up test
LOT	Lift-off test
SSC	Subscapularis
SSP	Supraspinatus

Introduction

Isolated subscapularis (SSC) tendon tears are relatively infrequent, and their diagnosis by clinical tests and radiological imaging is still challenging. The SSC tendon has a crucial role in shoulder biomechanics such as movement

(internal rotation) and centering of the humeral head; therefore, in case of symptomatic tendon lesions, it is recommended to repair [1]. Clinical results of arthroscopic repair of these uncommon tears have been reported in very few studies but seem to have good long-term outcome [2–4].

Many clinical tests have been described to detect SSC tendon tears yet all report different diagnostic capabilities. The bear hug test (BHT) has been proposed to have the highest sensitivity for SSC tendon tears [5–7]. Furthermore, Gerber et al. [8] described the belly press (BPT) and the lift-off test (LOT) as diagnostic tools for isolated SSC tears. Supraspinatus (SSP) tendon tears are less challenging to detect by clinical tests such as the Jobe test (JT) [9]. Bicipital involvement in SSC and SSP tears due to the anterior and posterior pulley lesion is frequent so that clinical assessment has to include the biceps tendon with the palm-up test (PUT).

The purpose of this study was to analyze the diagnostic value of the main tests for SSC and SSP tendon tears, their correlation between pain and strength on a clinical test, and compare them with intraoperative arthroscopic findings to prove their diagnostic value. The hypothesize was that clinical tests can reliably assess SSC tendon tears and that strength correlates with the size of the tendon tear.

Methods

In a prospective cohort study, 547 consecutive patients undergoing arthroscopic rotator cuff repair in a single center between January 2013 and September 2018 were included. The inclusion criteria were patients with isolated SSC, and anterosuperior tendon tear with a complete preoperative evaluation with clinical testing and operative report confirming the intraoperative findings. A group of patients with isolated SSP tendon tear served as a control group for intact subscapularis tendon. Exclusion criteria were patients that did not have a preoperative visit the night before the surgery and incomplete pre- or postoperative data as well as patients with isolated infraspinatus (ISP) tear and posterosuperior tendon tears (ISP and SSP).

Preoperative clinical testing was performed by the senior author (LL) and confirmed by a fellowship-trained orthopedic surgeon one day before surgery. The inter-rater reliability for all preoperative tests was calculated. The preoperative assessment includes BPT, BHT, LOT, PUT, and JT. In this study, the PUT was performed in a slight modification. The patient holds the arm like for JT but instead of internal rotation [10] in external rotation. With this modification, it is possible to test the superior part of SSC and the anterior part of SSP.

The testing was reported in two categories and one global evaluation index. The first category was pain on the testing recorded from 0 (maximum pain) to 15 (no pain during testing) according to pain assessment while performing a Constant–Murley score [11]. For simplicity, the pain scale was used in four possibilities: 0 (maximum pain), 5 (strong pain), 10 (slight pain), and 15 (no pain). The second category is strength, and it was reported according to manual muscle testing (MMT) in 5 categories, 0: no contraction, 1: muscle contraction without movement, 2: muscle movement without gravity, 3: complete full range of movement actively against gravity but not force, 4: complete full range of movement actively against some light resistance, 5: full range actively against strong resistance. The global evaluation was obtained by adding the results from both tests.

Patients were arranged into two groups according to the intraoperative findings: (1) isolated SSC, and (2) anterosuperior (AS) tendon tear. All of the patients were operated on by a single surgeon (LL). The tendon tears were intraoperatively reviewed, and the integrity of the SSC, the biceps, SSP, and ISP was assessed and classified according to the Lafosse classification [2] for SSC tendon tears and Patté [12] classification for supraspinatus tendon tear and reported in the 4D code [13] by the senior author. All intraoperative lesions of the anterosuperior rotator cuff are summarized in Table 1, and a flowchart of patient distribution is provided in Fig. 1.

Independent institutional review board approval was obtained from the Ethics Committee of the University of Lyon, Lyon, France (Comité de Protection des Personnes SUD-EST IV, Reference number L19-006).

Statistical analysis

The required sample size of 82 was determined by an a-priori power analysis to detect a medium effect size 0.3 of Spearman's rank correlation with a power of 0.80 and alpha error of 0.05. The prospectively collected data were retrospectively reviewed and all patients that met the inclusion criteria were included for further analysis.

Reliability was evaluated using intraclass correlation coefficients (ICCs) and a two-way mixed-effect model assuming an average measurement and absolute agreement.

Table 1 Lafosse classification of the intraoperative found tendon lesion

Type of Lesion	SSC ($n=39$)	SSC+SSP ($n=71$)
I	9.1%	31.0%
II	14.5%	14.5%
III	8.2%	11.8%
IV	3.6%	7.2%

SSC Subscapularis tendon; *SSP* Supraspinatus tendon

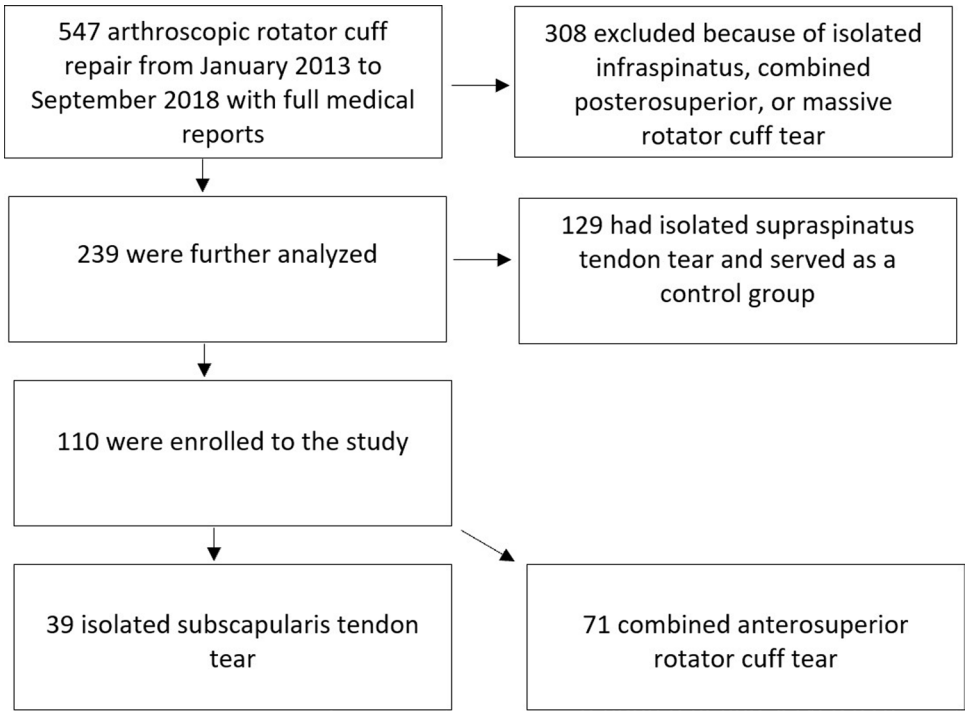

Fig. 1 Flowchart of the included cases

To assess the association between SSC lesion grade and the clinical test scores for strength and pain (BPT, BHT, LOT, PUT, and JT), Spearman's rank correlation was calculated. The same was done for the SSP lesion grade. SSP grade 3 and 2 lesions were pooled for statistical analysis as the sample contained only 4 grade 3 lesions. Spearman's rank correlation was tested against zero, and p values were corrected by the Bonferroni–Holm method. A multivariate analysis using linear regressions estimated by ordinary least squares (OLS) was conducted on surgical lesion grade (SSC) and clinical pain and strength codes. Surgical grade lesion was used as a dependent variable, while the clinical strength and pain scores were the independent variables. The different regression models were compared by F-tests. The sensitivity, specificity, positive predictive, value (PPV), negative predictive values (NPV), and accuracy were calculated for each clinical test (BPT, BHT, LOT, PUT, and JT). The significance of association was determined by Fisher's exact test. The significance level was set at 0.05. Statistical analyses were computed using Stata/IC 15.1 (StataCorp LP, College Station, TX, the USA).

Results

Out of 547 patients, 308 (56%) were excluded from further analysis because of isolated ISP, combined posterosuperior, or massive rotator cuff tear, and another 129 (24%) served as a control group with intact SSC tendon because of isolated SSP tendon tear. 110 patients (20%) were analyzed and allocated to the two described groups: 39 (7%) presented an isolated SSC tendon tear, and 71 (13%) combined SSP and SSC tendon tear, all of these patients underwent arthroscopic rotator cuff repair (Fig. 2).

The mean age of the included patients was 59 ± 10, while the SSC group has a mean age of 57 ± 9 years, and AP group 60 ± 10 ($p = 0.123$). In total, there were 22 female patients: 4 in the SSC group (10%), and 18 in SSC and SSP group (25%). All parameters are summarized in Table 2.

Global testing correlates with surgical finding

The test was considered negative when the patient achieved 20 points (15 for no pain and 5 for full strength). Interobserver reliability measured with ICC for BHT was 0.768 (95% CI: 0.604 to 0.864), BPT 0.729 (95% CI: 0.549 to 0.838), JT 0.647 (95% CI: 0.410 to 0.789), and PUT 0.668 (95% CI: 0.436 to 0.805) and indicates good reliability for BHT and moderate reliability for BPT, JT and PUT.

In all groups, the sensitivity of the BHT was 88.2%, of the BPT 74.5%, and of the LOT 80.9%, while specificity was only 41.9% for BHT, 45% for BPT, and 51.9% for LOT. In the presented study, the sensitivity was high (0.846), while the specificity was low (0.519). In the subgroup analysis with patients who had an isolated SSC or SSP tendon tear, the sensitivity of the BHT was 97.4%, while specificity was not changed. Analyzing for all groups, the sensitivity to find a SSP intraoperatively was 90.5% for JT and 87.5% for PUT, while specificity was only 41% for JT and 28.2% for PUT. All values are summarized in Tables 3 and 4.

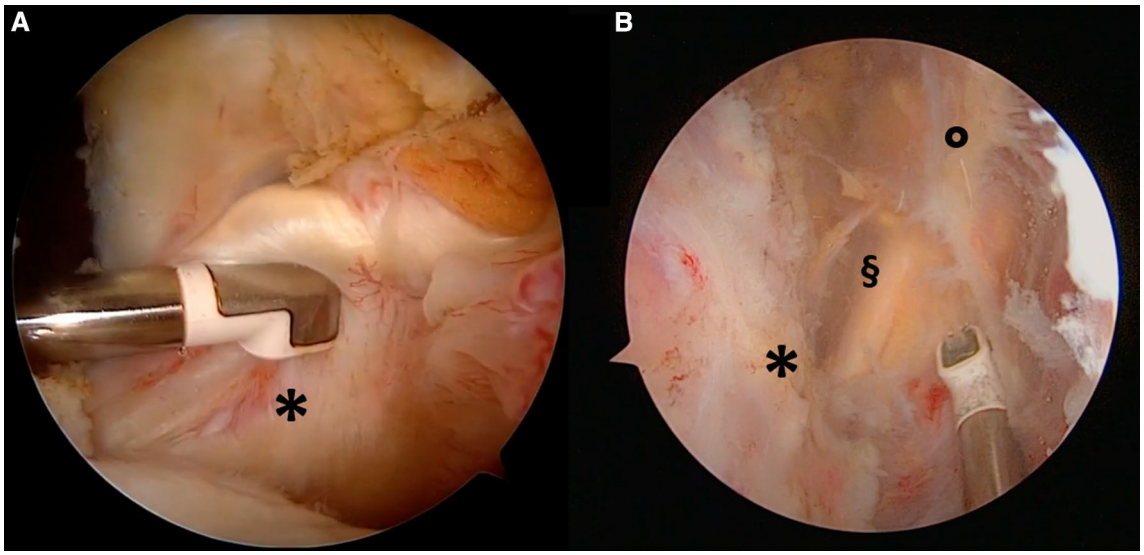

Fig. 2 Intraoperative arthroscopic view of a left shoulder from the posterior portal showing **A** a subscapularis (*) tendon rupture of the upper two-third (representing type III tendon rupture according to the Lafosse classification). Intraoperative arthroscopic view of a right shoulder from a lateral portal presenting **B** a massive traumatic subscapularis (*) tendon rupture (representing type IV according to the Lafosse classification) after extensive subcoracoid release showing the axillary nerve (§) and conjoined tendon (°)

Table 2 Demographic data of the included patients

	SSC ($n=39$)		SSP ($n=129$)		SSC & SSP ($n=71$)		Total ($n=239$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	57.5	9.0	58.0	9.8	60.4	9.9	**58.6**	**9.8**
Female	10%	31%	57%	50%	25%	44%	**40%**	**49%**
Right side	62%	49%	61%	49%	63%	49%	**62%**	**49%**

SSC Subscapularis tendon; *SSP* Supraspinatus tendon; *SD* Standard deviation

Table 3 Clinical tests for the subscapularis tendon

Lesion type	All SSC lesions					Isolated SSC				
Test	BPT+	BHT+	LOT+	JT+	PUT+	BPT+	BHT+	LOT+	JT+	PUT+
Sensitivity	0.745	0.882	0.809	0.827	0.836	0.718	0.974	0.846	0.590	0.718
Specificity	0.450	0.419	0.519	0.124	0.140	0.450	0.419	0.519	0.124	0.140
Accuracy	0.586	0.632	0.653	0.448	0.460	0.360	0.385	0.418	0.163	0.192
P value	0.002	0.000	0.000	0.359	0.717	0.067	0.000	0.000	0.000	0.052

BHT Bear hug test; *BPT* Belly press test; *JT* Jobe test; *LOT* Lift-off test; *PUT* Palm-up test; *SSC* Subscapularis tendon

Table 4 Clinical tests for the supraspinatus tendon and anterosuperior tendon lesion

Lesion type	Isolated SSP					AS	
Test	BPT+	BHT+	LOT+	JT+	PUT+	JT+ & BHT+	JT+ & BPT+
Sensitivity	0.550	0.581	0.481	0.876	0.860	0.803	0.732
Specificity	0.282	0.026	0.154	0.410	0.282	0.458	0.524
Accuracy	0.343	0.318	0.285	0.540	0.510	0.561	0.586
P value	0.067	0.000	0.000	0.000	0.052	0.000	0.000

AS anterosuperior; *BHT* Bear hug test; *BPT* Belly press test; *JT* Jobe test; *LOT* Lift-off test; *PUT* Palm-up test; *SSP* Supraspinatus tendon

Correlation pain and strength individually

A low positive correlation for an intraoperative SSC lesion and the strength of BPT (Spearman rank correlation −0.425; p value < 0.0001) and the strength of BHT (−0.362, M p value = 0.001) was found. A negligible correlation for an intraoperative SSC lesion and pain for BPT (−0.28; p value = 0.018) was found.

Correlation of surgical grade and preoperative clinical testing

Linear regression analysis estimated by ordinary least squares (OLS) was used to determine a correlation between surgical grade and strength or pain of clinical tests. 30 (12.5%) of patients were unable to perform Gerber's lift-off test. As a consequence of missing data, the LOT could not be included in the regression analysis. A significant correlation could be found for BPT strength and surgical grade of SSC lesion (−0.528; 95% CI, −0.923 to −0.133; p value < 0.01). No correlation could be found for JT and PUT to intraoperative findings.

Multivariate analyses of and clinical testing

We compared a regression model with strength and pain scores of the BPT, BHT, JT, PUT (Model 1) with a model using only strength and pain scores of the BPT and BHT (Model 2) as independent variables to analyze SSC lesion grade. For SSC tendon testing PUT and JT, neither strength nor pain provides additional information for the grade of the surgical SSC lesion (Model 1 vs. 2, $p = 0.873$). When BPT and BHT strength and pain are used as dependent variables together only BPT strength remains significant (coefficients BPT strength $p = 0.009$, BPT pain $p = 0.856$, BHT strength $p = 0.305$, BHT pain $p = 0.747$). The strength variables BPT and BHT exhibit higher adjusted R2 (0. 206 and 0.134) compared to the corresponding pain variables (R2 0.095 and 0.067) when used as a single-dependent variable to analyze SSC surgical lesion grade. Hence, strength, in particular BPT strength, explains a larger proportion of the difference in the SSC surgical grade than pain.

Discussion

This study showed a high sensitivity of the belly press (BPT) and bear hug test (BHT) to detect a subscapularis (SSC) tendon lesion with low specificity for both tests. In addition, a positive correlation for the preoperative assessed strength of the BPT with the intraoperative grade of SSC lesion was found. This study reports individually on five different preoperative clinical tests–belly press (BPT), bear hug (BHT), lift-off (LOT), palm-up (PUT), and Jobe test (JT)–for isolated SSC and anterosuperior rotator cuff tear (RCT) and evaluates its clinical value comparing it to the grade of the intraoperative lesion.

Isolated SSC tears are rare, and obtaining a large sample size is difficult. In the present cohort, clinical tests to detect SSC pathology and surgical repair were performed on 39 patients–representing 7% of patients with RCT–with isolated SSC lesions. Detecting and treating these lesions are important to restore internal rotation, as well as dynamic glenohumeral stabilization. Long-term functional and structural outcome of SSC repair shows satisfactory results [14]. The majority of patients showed lower grades of intraoperative found SSC tears (26% grade I, 41% grade II, and 23% grade III according to the Lafosse classification), while 10% showed a grade IV tendon rupture. In this cohort, all SSC lesions could be treated arthroscopically.

The diagnosis of a SSC tendon tear is challenging since MRI and physical examination have limited sensitivity [7]. Neyton et al. [15] also reported "hidden lesion of the subscapularis" that are challenging to diagnose even with arthroscopy. In most studies, clinical tests for SSC tendon tears have high specificity but low sensitivity [5, 6, 16]; contrary to our study by modifying the positive value of the testing to 0–19, the current study had a higher sensitivity sacrificing the specificity. Most studies report either on negative or positive test results if patients have a lack of strength for internal rotation or inability to perform internal rotation, e.g., lack of hand extension during belly press test. This is the first study that adds a grading of strength and pain and correlates the preoperative testing value to the intraoperative found tendon lesion. However, in daily clinical life, a testing value of 19 (pain 15+strength 4) or 15 (pain 10+5) can indicate a negative result, especially for a surgical indication. Furthermore, Bartsch et al. [17] reported that 24% of the cases with a SSC tendon tear had normal testing so it remains demanding to detect a clinically relevant SSC tendon tear. Yoon et al. [18] showed a highly specific positive LOT for a full-thickness SSC tendon tear with severe fatty infiltration of the SSC muscle. This test showed relatively poor sensitivity (35%) for discriminating the presence of any tear. In the present study, the sensitivity was high (0.846), while the specificity was low (0.519). The hypothesis of assuming only 20 as a negative test leads to very high sensitivity sacrificing specificity. In a clinical setting, painful subacromial bursitis or a biceps pathology can also lead to a painful SSC test and therefore influence the pain value in our classification.

Another important finding of this study is that with our classification of grading the strength and pain, the BPT shows a (low) correlation for strength and intraoperative grading of the SSC rupture (−0.528; 95% CI, −0.923 to −0.133; p value < 0.01). This finding corresponds with

other studies [5, 18]. Otherwise, no correlation was found between pain grading and intraoperative found size of tendon lesion. This is due to the fact that pain is not always directly related to a tendon tear. Itoi et al. [19] showed that pain in shoulders with rotator cuff tear is most likely associated with subacromial bursitis and not to the site of the (supraspinatus) tear. In addition, the same study showed higher accuracy of clinical tests when the muscle weakness is assessed. Therefore, this study focused on rotator cuff strength when evaluating surgical indications for rotator cuff repair. Nevertheless, by considering pain and strength a positive result, the sensitivity of the tests could be increased as suggested by Barth et al. [5] In a different study [20], pain was not considered a positive result, and the sensitivity was lower (LOT 65.2 and BHT 73.7) than in the present study. The advantage of performing a BHT comparing to a LOT is that upper or inferior tendon lesion can be differentiated [6, 21], and the test is even positive in smaller SSC lesions. However, it is important that a limitation of range of motion —especially internal rotation— can limit the clinical evaluation of BPT. Therefore, the BHT shows an advantage in the clinical evaluation since the limitation of internal rotation does less influence the result of this test.

An advantage to another study [18], the current study also included combined anterosuperior RCT or isolated SSP tear for further analysis, since combined SSC and SSP lesion are commonly found during arthroscopy [22]. Therefore, in this study, the PUT was performed in external rotation instead of the initially described internal rotation [10]. With this modification, it is possible to test the superior part of SSC and the anterior part of SSP, as well as the rotator interval which are just under the tip of the acromion. This is expressed by the high sensitivity for all SSC lesions (0.836) and all SSP lesions (0.875) of the PUT.

To distinguish between SSC and SSP with the studied tests is still very difficult because of the low specificity of the tests. The sensitivity instead is for every test quite high. The sensitivity for the subscapularis tests (BPT, BHT and LOT) to detect a SSC tendon is high, while JT showed low specificity (0.124) and sensitivity (0.590) for isolated SSC tendon lesion (Table 3). Both specificity and sensitivity for the SSC tests were low to detect a SSP tendon tear (Table 4). Furthermore, there exists a correlation between strength and pain to detect a SSC tendon tear, but a much higher correlation can be achieved with the strength. Finally, the BPT shows a higher correlation with preoperative findings and intraoperative grade of SSC tendon lesion, again strength seemed to be more powerful for a tear prediction than pain.

Limitation

This study has several limitations. First, there was a low number of patients with an isolated SSC tendon lesion. Second, the clinical evaluations were performed by different examinators for almost 6 years, and a subjective grading from 0 to 5 was used. Interobserver reliability analysis is difficult to interpret because of the different examinators. The senior author confirmed all clinical tests during his outpatient clinic preoperatively, and the tests were performed again by orthopedic surgeons with specialization in shoulder surgery the day before surgery. Third, concomitant pathologies of the proximal long head of the biceps tendon nor acromioclavicular arthropathies were not excluded. These pathologies may also influence the result of rotator cuff testing and were not further analyzed.

Conclusion

The BHT showed a higher sensitivity for a SSC lesion, while the BPT had a higher correlation between preoperative testing, most notably internal rotation strength, and intraoperative surgical grade of the SSC tendon lesion.

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Declarations

Conflict of interest Laurent Lafosse is consultant, receives royalties, hold stocks of DePuy, Oberdorf, Switzerland. All other authors have no conflict of interest.

Ethical approval Independent institutional review board approval was obtained from the Ethics Committee of the University of Lyon, Lyon, France (Comité de Protection des Personnes SUD-EST IV, Reference No. L19-006).

Informed consent All patients provided written informed consent before participation.

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