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SHOULDER

Arthroscopic Trillat procedure combined with capsuloplasty: an effective treatment modality for shoulder instability associated with hyperlaxity

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Abstract

Purpose The aim of this study was to describe the results of an arthroscopic Trillat procedure utilized to treat patients with symptomatic antero-inferior shoulder instability associated with hyperlaxity.

Methods A retrospective review was performed on 19 consecutive shoulders (17 patients, 2 bilateral) who underwent a Trillat procedure combined with anterio-inferior capsulolabral plasty from 2016 to 2019. Patients included in the study presented with shoulder instability combined with shoulder hyperlaxity and no glenoid or humeral bone loss. Clinical assessment included range of motion, apprehension, and instability tests. Outcome measures Constant–Murley score (CMS) scale, Walch-Duplay, ROWE, Subjective Shoulder Value (SSV), Visual Analogue Scale (VAS). Post-operatively, healing of the coracoid osteoclasy was evaluated by CT scan.

Results The mean follow-up was 24.8 months (range, 12–51). Post-operatively, none of the patients experienced a recurrent dislocation or subluxation and the anterior apprehension test was negative in all shoulders. Post-operative motion deficits of $22.1° \pm 15.8$ [$p < 0.05$] and $12.4° \pm 10.1$ [$p < 0.05$] loss were documented for ER1 and ER2, respectively. All functional scores exhibited significant improvements. Post-operative CT scan was available in 16 shoulders and revealed coracoid union in 15/16 shoulders and an asymptomatic fibrous non-union without coracoid or implant migration in one patient.

Conclusion The arthroscopic Trillat procedure combined with an antero-inferior capsulolabral plasty is effective in preventing recurrent instability and eliminating shoulder apprehension among patients suffering from anterior and or inferior hyperlaxity.

Level of evidence Level IV.

Keywords Shoulder instability · Hyperlaxity · Trillat Procedure · Capsuloplasty · Endobutton

Introduction

Patients with symptomatic shoulder hyperlaxity and instability are challenging to treat and can experience treatment failure with conventional methods of arthroscopic and open procedures [10, 15]. Increased collagen laxity affects the primary static joint stabilizers with increased capsular volume and lengthening of the glenohumeral ligaments resulting in pain and shoulder dysfunction [11, 12, 16]. Additionally, free bone block procedures such as Latarjet or Eden-Hybinette are not successful options given that lack of glenoid bone loss and resulting resorption of graft bone over time [5, 18].

In 1954, Albert Trillat [9, 23] described a surgical technique involving a closing wedge coracoid osteoclasy (partial osteotomy) that redirects the coracoid tip in a distal and

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medial direction in association with an anterior capsule retensioning. In its new position, the conjoint exerts blocking effect on anterior translation of the humeral head when placing the arm in an abduction and external rotation position [4, 17, 22]. The Trillat procedure was found to provide effective and durable results for the treatment of shoulder instability for patients with both an irreparable rotator cuff tear and a functional subscapularis [13, 25].

Recently, an arthroscopic Trillat procedure [22] combined with capsulolabral plasty [24] was suggested as an alternative treatment for shoulder instability associated with shoulder hyperlaxity without glenoid or humeral bone loss [24].

The purpose of this study was to describe the results of an arthroscopic Trillat procedure for patients with symptomatic antero-inferior shoulder instability associated with hyperlaxity, with respect to recurrent instability, apprehension, range of motion, and functional results. We hypothesized that a combined arthroscopic Trillat procedure and anterior-inferior capsulolabral plasty would provide effective shoulder stability with elimination of apprehension and significant improvement in functional outcome scores but with some motion deficits, especially in external rotation.

Materials and methods

Study design, and inclusion and exclusion criteria

This is a retrospective review of 19 consecutive shoulders (17 patients, 2 bilateral) who underwent a Trillat procedure combined with anterio-inferior capsulolabral plasty from 2016 to 2019. Operations were performed in a single institution and were retrospectively assessed. The study was approved by the clinic local ethical committee (local ethical committee Ambroise Pare–Pierre Cherest–Hartmann; IRB 00012608).

Patients were included in the study if they exhibited shoulder instability combined with shoulder hyperlaxity and no glenoid or humeral bone loss. Instability was defined as at least one episode of shoulder dislocation or subluxation in an anterior and or inferior direction. Patients presented either a unidirectional anterior or inferior hyperlaxity, or a combined bidirectional antero-inferior hyperlaxity [11]. Anterior hyperlaxity was assessed in the standing position and was considered positive if active shoulder external rotation with the arm at the side of the body (ER1) was 85° or greater [2]. Inferior hyperlaxity was confirmed by the presence of a positive Gagey sign [27].

Additional inclusion criteria were: (1) a positive anterior apprehension test [29], (2) absence of bony glenoid or humeral lesions on Computed Tomography (CT) Arthrogram or Magnetic Resonance Imaging (MRI), (3) failed conservative treatment, and (4) a minimum follow-up of 12 months.

Patients excluded from the study if they presented with (1) posterior shoulder hyperlaxity or instability; (2) absence of shoulder hyperlaxity; (3) previous shoulder operation other than anterior bankart repair or capsuloplasty; (4) plain radiographs demonstrating osteoarthritis according to Samilson–Prieto classification [21]; (5) multidirectional instability associated with hyperlaxity; (6) irreparable subscapularis tear.

Surgical technique

All surgeries were performed by the senior author using a technique previously described by Valenti et al. [24] (Figs. 1, 2). Operations are performed in the beach chair position under general anesthesia and interscalene block. Prior to performing the coracoid osteoclasy, the antero-inferior capsulolabral complex shift is performed and three capsulolabral sutures are passed. Next, the coracoid osteoclasy is performed by exposing the coracoid neck, detaching coracoacromial ligament, pectoralis minor tendon, and partially osteotomizing the base of the coracoid with a burr. The glenoid recipient site on the superior glenoid between 12 and 2 o'clock (right shoulder) is performed. A glenoid drill guide (arthroVIMS Button, VIMS, France) is inserted through the posterior portal with its distal blade laying on the anterior glenoid rim at the previously prepared 12 to 2 o'clock position (right shoulder). A cannulated 3.2 mm drill bit is introduced posteriorly through the guide and a glenoid tunnel is created. A specific guide is used to create a corresponding 3.2 mm coracoid tunnel. Using a shuttle relay technique, cortical endobuttons (arthroVIMS Button, VIMS, France) are introduced to the posterior glenoid and superior coracoid. Tensioning of the sutures results in reduction of the coracoid inferiorly and medially to the glenoid recipient site. Sufficient sub-coracoid space for smooth and impingement free gliding of the subscapularis tendon is verified. Finally, the three previously placed capsulolabral sutures are secured to the glenoid using three knotless suture anchors (PushLock 2.9 mm, Arthrex).

Clinical and radiographic evaluation

Post-operative visits were scheduled at 6 weeks, 3 months, 6 months, and yearly thereafter. Preoperative and post-operative clinical evaluation included examination of shoulder active range of motion (ROM) and anterior apprehension test.

Shoulder hyperlaxity was examined preoperatively using the Gagey test to determine the presence of inferior laxity and active external rotation in a position of adduction (ER1) for anterior laxity [27]. Apprehension test was performed

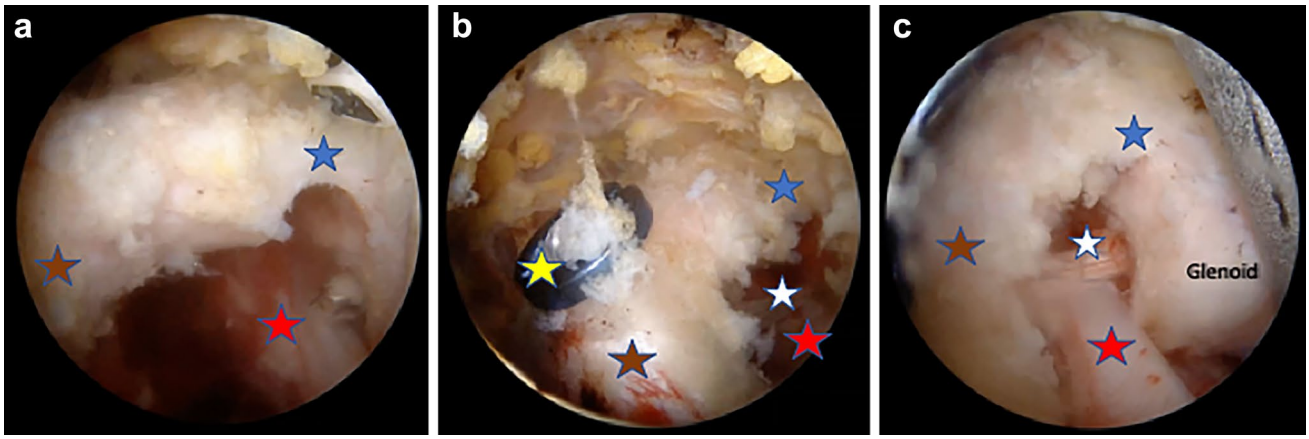

Fig. 1 **A–C** Intra-operative images. Blue star marks the osteoclasy site. Red star marks the subscapularis muscle. Brown star marks the tip of coracoid process associated with the conjoined tendon. Yellow star marks the coracoid endobutton. White star demonstrates the endobutton strands. **A** Coracoid osteoclasty prior to coracoid bending. **B** Coracoid endobutton position. **C** Final coracoid and conjoined tendon position. Note the distal and medialized position of the coracoid, intact superficial coracoid cortex, and superior exit of the endobuttons strands from the glenoid above the subscapularis muscle

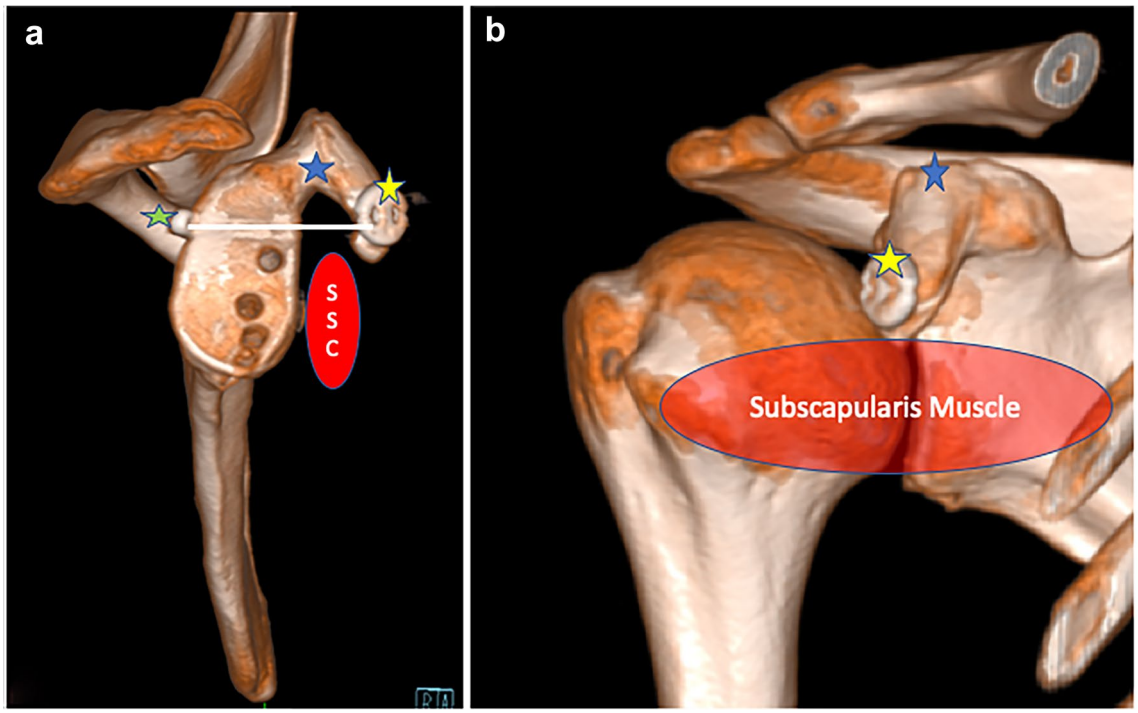

Fig. 2 3D reconstruction CT with sagittal and coronal views—Post-Trillat and Capsuloplasty Procedure. The coracoid process is medialized and distalized demonstrating an osteoclasy healing: red ellipse featuring subscapularis muscle (SSC) location posterior to the redirected coracoid. Blue star marks the consolidated osteoclasy site. Yellow star demonstrates coracoid endobutton. Green start demonstrates posterior glenoid cortical button. White line demonstrates the endobutton strands passing in the tunnel created through the superior glenoid and ending on the coracoid tip. **A** Sagittal view. **B** Coronal view

in standing position and involved the passive positioning of patient's arm in abduction and external rotation [29]. ROM evaluation was performed using a goniometer and included external rotation assessed at 90° of abduction (ER2), forward flexion, and internal rotation. External rotation and forward flexion were assessed in degrees. Internal rotation assessment was based on Constant–Murley score (CMS) scale.

Patients' functional outcomes were assessed using the following functional scores: Walch-Duplay, ROWE, CMS, and Subjective Shoulder Value (SSV). Post-operative recurrent

episodes of instability manifested as dislocation or subluxation events were recorded. Recurrence was defined as a new episode of frank dislocation requiring a manipulative reduction or as a subjective sensation of shoulder subluxation described by the patient. Patient's return to sport was retrieved from the functional scores. Visual Analogue Scale (VAS) was used for pain assessment, whereas satisfaction level was documented at the last follow-up and was rated by the patients as either (1) very satisfied; (2) satisfied; (3) acceptable; (4) unacceptable.

Preoperatively, plain radiographs including anterior–posterior (AP) views in internal, neutral, and external rotation, axillary view and outlet view, CT arthrograms, or MRIs were used to evaluate the presence of the following: (1) glenoid or humeral head bony lesion (2) capsulolabral lesion; (3) glenohumeral joint arthritis according to Samilson–Prieto [21]. Post-operatively, healing of the coracoid osteoclasy was evaluated by CT scan and osteoarthritis by plain radiographs. Complications and reoperations were also documented.

Statistical analysis

All statistical analyses were performed using SPSS Statistics software. Descriptive statistics are described as minimum, maximum, mean, and standard deviation for continuous measures and number (percentage) for discrete variables. A Student's *t* test was used to compare pre-operative and post-operative state for quantitative values and the data are presented as mean difference ± SD. A post hoc sample size calculation was performed utilizing the R version 4.0.3 software, indicating that a sample size of 14 patients is required to reach a power of 80%.

Results

Nineteen shoulders in 17 patients (10 females, 7 males) participated in the study. The study was approved by an ethical committee and all patients signed an informed consent. An average age of 25 years (range, 16–51; SD 8.9) was noted at the time of the surgery. The mean follow-up was 24.8 months (range, 12–51; SD 8.7). Patients' demographics, sport activity level, laterality, and number of dislocations preceding the operative treatment are detailed in Table 1.

Data regarding direction of instability, type of instability, prior stabilizing procedures, and additional intra-operative findings are detailed in Table 1.

Post-operatively, none of the patients experienced a recurrent dislocation or subluxation and the anterior apprehension test was negative for all shoulders. Range of motion assessment identified a significant reduction in all motion planes with the exception forward flexion (Table 2).

Post-operatively, all tested functional scores exhibited significant improvements, as demonstrated in Table 2. Two patients, one of each group, did not return to the same sport level (Table 2). The final outcome was declared as very satisfactory in 15 procedures and as satisfactory in four procedures. No patient described an acceptable or unacceptable outcome.

Post-operative osteoclasy healing assessment by CT scan was available in 16 shoulders and unavailable in three patients who declined an additional scan (Fig. 2). Healing was confirmed for all but one coracoid osteoclasy that remained asymptomatic without coracoid or implant migration. No arthritic changes occurred on post-operative radiographs.

With regard to patients' complications, one intra-operative coracoid fracture occurred during the bending process of the coracoid. The patient was later on detected with a non-union of the osteotomy site. Pre- and post-operative data of the all patients are detailed in Table 2. No further complications were noted in this study.

Discussion

The main findings of the study suggest the procedure to be effective in restoring glenohumeral stability and elimination of apprehension at a mean 24.8 month follow-up. Significant improvement occurred for all functional outcome scores. However, shoulder ROM was noted to be significantly decreased in ER and internal rotation after this procedure.

A new episode of instability nor a sensation of apprehension post-operatively was experienced by none of the patients in our study. Two patients in our series were unable to resume their pre-operative level of sport and all patients declared to be either very satisfied or satisfied from the final surgical outcome.

The treatment of instability associated with hyperlaxity by conventional arthroscopic Bankart repair has been shown to result in high recurrence rates [3, 26]. Balg and Boileau [2] identified shoulder hyperlaxity as a risk factor for the development of post-arthroscopic Bankart repair instability [2, 3]. Abdelhady et al. [1] recommended the Latarjet procedure for treatment of recurrent instability in the setting of capsular laxity. Finally, a study evaluating the long-term result of the Latarjet procedure [17] determined the technique to be effective in patients suffering from recurrent traumatic anterior instability with or without hyperlaxity. With relation to the Latarjet procedure, some authors recommend a modification of the site of subscapularis split to a more superior location to maximize the sling effect of the subscapularis and conjoined tendon [28]. As in the Trillat procedure, it is assumed that a higher split location recruits a larger portion of the subscapularis muscle, which results

Table 1 Demographic data

	Study group 19 shoulders	
Age at surgery	25 ± 8.9 (16–51)	
FU (months)	24.8 ± 10.2 (12–51)	
	F	M
Gender	10	7
	L	R
Affected side	6	13
Dominant side	0	17
Sport activity		
Competition	4	
Leisure	7	
Number of instability episodes prior to surgery	Number	Percentage (%)
I	4	21
II	5	26.3
III	1	5.3
IV	1	5.3
Multiple	8	42.1
Direction of instability		
Anterior	12	
Anterior + inferior	7	
Type of instability		
Dislocation	13	
Subluxation	6	
Anterior apprehension	19	
Previous surgery		
Anterior bankart	1	
Anterior capsuloplasty	1	
Intra-operative non-bony bankart lesion	5	

FU follow-up

on one hand in an improved stability, but, on the other hand, may potentially impair external rotation due to impingement between the subscapularis muscle and the conjoined tendon [8, 19].

Doubt regarding the Latarjet procedure's outcomes was raised in individuals without a glenoidal bony lesion. Moroder et al. identified that a Latarjet procedure performed on a "healthy" glenoid without bone loss will result in graft resorption due to decreased strain levels or lack of graft loading [18]. Additionally, Hardy et al. [8] similarly found an inverse relation between pre-operative glenoid defect size and post-Latarjet graft osteolysis and pain levels. Given the high recurrence rate [5] with soft tissue only procedures, [2, 3] in the setting of intact glenoid bone [8, 18], one should consider the Trillat procedure as it appears to offer an effective and safe alternative.

Gerber et al. [7] reported the results of 52 shoulders treated with Trillat procedure for either anterior instability associated with bony lesions or multidirectional instability. They [7] described a 4% recurrence rate, severe post-operative pain, loss of external rotation, and a severe dislocation arthropathy related to coracoid tip impingement and its positioning in a lateral and or posterior location. Progressive osteoarthritis and 16% recurrence of instability were reported by Walch et al. [25] in their study of 24 patients treated for anterior instability associated with irreparable cuff tear. Therefore, coracoid positioning appears to play a crucial role in the development of post-operative pain and osteoarthritis, two complications that may be avoided using the described arthroscopic technique.

The arthroscopic Trillat procedure [24] offers a reliable effective method for treating recurrent, symptomatic shoulder instability in the setting of hyperlaxity. The technique allows the verification of a smooth subscapularis gliding under the redirected coracoid and the absence of sub-coracoid impingement which may otherwise result in external rotation limitation and severe post-operative pain [7]. The use of cortical buttons under direct vision enables to precisely adjust the tension applied on the coracoid tip and therefore avoids excessive tightening of the anterior soft tissue. Finally, the use of low-profile cortical buttons over the coracoid, instead of screws, offers a safer method of graft

Table 2 Pre- and post-operative results of the study group (19 shoulders)

Variable	Pre-op Post-op Delta *P* value	Study group 19 shoulders
FE (°)		172 ± 24.2 (80–180)
		173.7 ± 9.6 (150–180)
		1.6 ± 20.1 (−20–70)
		N.S
ER1 (°)		91.1 ± 4.6 (80–100)
		69 ± 14.1 (40–90)
		−22.1 ± 15.8 (−60–0)
		< 0.05
ER2 (°)		91.6 ± 3.7 (90–100)
		79 ± 8.9 (60–90)
		−12.4 ± 10.1 (−30–0)
		< 0.05
IR (grade)		85.3 ± 9.6 (60–90)
		76.8 ± 10 (60–90)
		−8.4 ± 13 (−30–20)
		< 0.05
Constant (X/100)		67.1 ± 10.6 (35–78)
		81.2 ± 3(75–87)
		14.1 ± 9.5 (1–40)
		< 0.05
Walch-Duplay (/10)		30.8 ± 19.9 (−25–65)
		91.8 ± 11.7 (60–100)
		61.1 ± 17.9 (20–85)
		< 0.05
ROWE (%)		32.1 ± 12.9 (0–55)
		95.8 ± 9.3 (60–100)
		63.7 ± 11.2 (45–80)
		< 0.05
VAS (X/10)		2.2 ± 1.7 (0–5)
		0.2 ± 0.5 (0–2)
		−2 ± 1.6 (−4–1)
		< 0.05
SSV (%)		58.4 ± 11.7 (30–70)
		88.4 ± 6.9 (70–100)
		30 ± 12 (10–60)
		< 0.05
Resuming sports activity		
Same level		9/11
Reduced level		2/11
Satisfaction		
VS		15
S		4
A		0
U		0

FE forward elevation in degrees; *ER1* external rotation arm at the side to the body; *ER2* external rotation arm at 90° abduction; IR internal rotation; *VAS* Visual Analogue Scale; *SSV* subjective shoulder value; *VS* very satisfied; *S* satisfied; *A* acceptable; *U* unsatisfied; *NS* non-significant

fixation with reduced risk of iatrogenic neurological injury and decreased need for delayed hardware removal [6, 14, 20].

The significant ROM loss demonstrated in our study, in particular, that of external rotation, may be explained by the combined effect of antero-inferior capsuloplasty and the augmented sling effect created by the recruitment of the entire subscapularis muscle by the conjoined tendon. Gerber et al. [7] also reported a high degree of ER loss and noted that a greater than 30° loss of ER was related to the development of a severe degree of shoulder arthropathy. In this study short follow-up, an average of 22.1° loss in active shoulder external rotation with the arm at the side of the body (ER1) was not accompanied by development radiological signs of osteoarthritis.

In the present study, one patient demonstrated an asymptomatic non-union of the coracoid osteoclasy at 15 months post-operatively. This was attributed to an intra-operative coracoid fracture due to imbalanced pulling on the coracoid during the bending process. At the last follow-up, the patient remained pain free and reported a very satisfied subjective evaluation.

Limitations of the study include its retrospective nature, the relatively small number of patients, short follow-up period, and the lack of a control group undergoing either an isolated Latarjet procedure or an isolated capsuloplasty.

The clinical relevance of our work suggests that patients suffering from the challenging pathology of shoulder instability associated with hyperlaxity but with no bone loss are likely to benefit from the offered operative solution. The procedure generates its effect through a combination of two well-established techniques, a classical capsuloplasty together with a dynamic stabilization technique.

Conclusion

At a short-term follow-up, the arthroscopic Trillat procedure combined with an antero-inferior capsulolabral plasty was shown to be effective in preventing recurrent instability and eliminating shoulder apprehension among patients suffering from anterior and or inferior hyperlaxity. Compared to pre-operative state, significant improvement was demonstrated in all functional score, whereas a decline was observed in all ROM parameters except forward elevation.

Author contributions EK—literature search, data analysis, data interpretation, and writing. NM-C—data collection, data analysis, and data interpretation. RO—data collection, data analysis, and data interpretation. JKE—literature search, study design, data analysis, data interpretation, and writing. JDW—literature search, study design, data analysis, data interpretation, and writing. PV—literature search, study design, data analysis, data interpretation, and writing.

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Declarations

Conflicts of interest None.

Ethical approval This study was classified as observational (non-interventional) by our local ethics committee Statutory and ethical obligations of observational (non-interventional) studies in France: According to the past Huriet law on biomedical research, and to the current regulation that went into effect in August 2006 (law no. 2004-806), such studies do not require prior submission or approval to/from an IRB, and they do not require written consent. There is a current discrepancy on observational studies between the French legal requirements and the editors' requirements. This observational research on data fulfills current French regulatory and ethical obligations.

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