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# Subscapularis management during open Latarjet procedure: does subscapularis split versus tenotomy matter? A systematic review and meta-analysis

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**Background:** The purpose of this study was to systematically review the literature to ascertain the clinical outcomes of the open Latarjet (OL) procedure using either a subscapularis-split (SS) or subscapularis tenotomy (ST) via a deltopectoral (DP) approach.

**Methods:** Two independent reviewers performed a literature search using the PubMed, Embase, and Scopus databases according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines. Only studies reporting on outcomes of the OL procedure via a DP approach comparing both SS and ST were considered for inclusion. Meta-analysis to compare clinical outcomes was performed using RevMan software.

**Results:** Our search found 5 studies that met our inclusion criteria, including 615 shoulders (80.8% male patients), with an average age of 27.8 ± 12.6 years (range, 15-79 years) and mean follow-up period of 50.1 ± 29.4 months (range, 12-180 months). A total of 410 shoulders and 205 shoulders underwent the OL procedure via a DP approach using the ST technique and the SS technique, respectively, with both techniques resulting in significant increases in the Rowe score postoperatively ($P < .0001$ for both). Additionally, significantly higher postoperative Constant scores were observed in patients who underwent the OL procedure via an SS technique vs. those in the ST group (91.8 ± 7.2 vs. 79.6 ± 16.1, $P < .0001$). However, meta-analysis showed nonsignificantly higher postoperative Rowe and American Shoulder and Elbow Surgeons scores in patients who underwent the OL procedure via an SS technique vs. those in the ST group (96.1 ± 2.6 vs. 86.4 ± 7.6 [$P = .57$] and 91.6 ± 1.3 vs. 80.6 ± 25.5 [$P = .47$], respectively). Furthermore, meta-analysis showed that significantly more patients in the ST group had positive lift-off test results (10.0%) when compared with the SS group at final follow-up (2.7%, $P = .01$). However, meta-analysis indicated that the rate of recurrent instability was trending toward significance in favor of the SS group (0% vs. 11.7%, $P = .07$).

**Conclusion:** Our systematic review established that in cases of OL procedures being carried out via a DP approach, the SS technique results in significantly better functional outcome measures and significantly lower rates of subscapularis insufficiency when compared with an L-shaped ST technique at medium-term follow-up. Furthermore, there were lower rates of recurrent instability that were trending toward significance in favor of the SS technique.

**Level of evidence:** Level III; Meta-analysis and Systematic Review



**Keywords:** Open Latarjet; deltopectoral approach; subscapularis; split; tenotomy; systematic review

Institutional review board approval was not required for this systematic review.

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Anterior shoulder instability is a common issue affecting up to 2% of the general population,[12,21] with the incidence being much higher in collision athlete cohorts.[11] In cases of high volumes of glenoid bone loss, the open Latarjet (OL) procedure has been shown to result in excellent clinical outcomes and high rates of return to play in the short term, as well as low revision rates in the long term.[2,3,8,10]

The subscapularis muscle is the strongest of the rotator cuff musculature, playing a key role in active dynamic stabilization of the anterior glenohumeral joint.[13] Because the OL procedure is commonly carried out using a deltopectoral (DP) approach, discrepancies in opinion among surgeons exist in relation to subscapularis management during the approach as optimal subscapularis function after the OL procedure is of concern.[19] Many surgeons use a subscapularis-split (SS) technique during their DP approach, whereby the subscapularis is repaired after coracoid transfer, whereas others perform an L-shaped subscapularis tenotomy (ST) to allow optimal visualization of the glenoid labrum.[4] In a comparative study, Scheibel et al[20] reported that the use of ST during the OL procedure via a DP approach may potentially lead to atrophy and fatty infiltration of the subscapularis muscle postoperatively, resulting in muscular insufficiency, yielding inferior clinical outcomes after the OL procedure. Recent consensus guidelines have stated that an SS technique should be used to access the glenohumeral joint during the Latarjet procedure; however, the majority of the literature is based on comparative studies without any meta-analysis comparing these approaches.[9]

Therefore, the purpose of this study was to systematically review the literature to ascertain the clinical outcomes of the open OL procedure using either an SS or ST via a DP approach. Our hypothesis was that the ST technique would result in inferior functional outcomes when compared with the SS technique for the DP approach in cases of OL procedures.

## Materials and methods

### Search strategy

Two independent reviewers (M.S.D. and E.T.H.) carried out a literature search according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines using the PubMed, Embase, and Scopus databases in December 2021. The following search terms were used for all 3 databases: (open Latarjet or OL or bone block or open shoulder stabilization) and (subscapularis) and (split or repair or tenotomy). It was predetermined that no time limit would be applied to the search. After duplicate studies had been removed, both reviewers manually screened the titles and abstracts of all studies identified by the initial search while applying our exclusion criteria. In the instance of discrepancies in opinion between the 2 reviewers, the senior author (H.M.) acted as an arbitrator. Thereafter, both reviewers independently evaluated the full texts of all potentially eligible studies using predetermined inclusion criteria.

### Eligibility criteria

Prior to search commencement, both independent reviewers and the senior author agreed on the predetermined inclusion and exclusion criteria and data collection sheet to be used for this study. The inclusion criteria for this study included the following parameters: (1) studies comparing the clinical outcomes of patients following the OL procedure via a DP approach using either the ST or SS technique, (2) studies published in the English language, and (3) studies published in a peer-reviewed journal. The exclusion criteria included (1) studies focusing on outcomes after the OL procedure via a DP approach with ST or SS alone, (2) biomechanical studies, (3) cadaveric studies, (4) abstract-only studies, and (5) case reports.

### Data extraction

Using the aforementioned predetermined data collection sheet, the 2 reviewers independently evaluated the published manuscripts of the included studies with a focus on gathering all relevant data. Study characteristics and patient demographic characteristics of interest included (1) mean follow-up period, (2) level of evidence, (3) methodologic quality of evidence (MQOE), (4) number of included shoulders, (5) mean patient age, and (6) patient sex. The criteria previously established by Wright et al[22] and Robertson et al[17] were used to evaluate each study's level of evidence and MQOE, respectively.

### Statistics

Descriptive statistical analysis was performed using IBM SPSS Statistics for Windows software (version 22.0 [released 2013]; IBM, Armonk, NY, USA). For continuous data, an independent-sample $t$ test was used to decipher differences in mean values between groups, whereas the Fisher exact test was used to decipher differences between groups for categorical data.

One investigator (M.G.D.) then performed a meta-analysis on the studies involving clinical outcomes that were reported in >1 included study; this was carried out using Review Manager software (RevMan for Macintosh, version 5.4 [released 2020]; The Nordic Cochrane Centre/The Cochrane Collaboration, Copenhagen, Denmark). Thereafter, lift-off test analyses and rates of recurrent instability in the SS and ST groups were expressed as dichotomous or binary outcomes, reported as odds ratios and corresponding 95% confidence intervals, following estimation using the Mantel-Haenszel method. In contrast, continuous data (ie, Rowe, Constant, and American Shoulder and Elbow Surgeons [ASES] scores) were calculated using mean values, standard deviations, and pooled mean variance. Either fixed- or random-effects models were applied based on whether significant heterogeneity ($I^2$ >50%) existed between studies included in the analysis. Statistical heterogeneity was determined using the $I^2$ statistic. $P < .05$ was deemed statistically significant.

## Results

### Literature search

The initial literature search resulted in a total of 953 studies. After the removal of 157 duplicates, the remaining 796 studies were screened using our exclusion criteria. Thereafter, our inclusion criteria were applied to the full texts of the remaining 101 studies to screen for eligibility. Overall, 5 clinical studies including 615 shoulders were included in our study.[5,6,14-16] A summary of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flowchart is presented in Figure 1.

### Study characteristics and patient demographic characteristics

A total of 5 studies (all level III evidence) met our inclusion criteria, comprising 615 shoulders, with a mean MQOE value of 45.7 (range, 29-52). Overall, the majority of patients were male patients (80.8%); the average age was 27.8 ± 12.6 years (range, 15-79 years), and the mean follow-up period was 50.1 ± 29.4 months (range, 12-180 months). A total of 410 shoulders and 205 shoulders underwent the OL procedure using the ST technique and SS technique, respectively. A summary of study characteristics is presented in Table I.

### Clinical outcomes

Two studies reported preoperative and postoperative Rowe scores following the OL procedure using both the ST and SS techniques. The mean preoperative Rowe score in the ST group (284 patients) was 45.3 ± 14.9, with a significant increase in the mean Rowe score to 86.4 ± 7.6 postoperatively ($P < .0001$). Similarly, the mean preoperative Rowe score in the SS group (140 patients) was 43.7 ± 15.8, with a significant increase in the postoperative Rowe score to 96.1 ± 2.5 ($P < .0001$).

Descriptive analysis showed that postoperative Rowe scores were significantly higher in patients who underwent the OL procedure using an SS technique vs. those in the ST group (96.1 ± 2.6 vs. 86.4 ± 7.6, $P < .0001$). However, meta-analysis subsequently found that postoperative Rowe scores were not significantly higher in patients who underwent the OL procedure using an SS technique vs. those in the ST group ($P = .57$).

Additionally, 2 of the included studies reported both ASES and Constant scores following the OL procedure. Descriptive statistics showed that postoperative ASES and Constant scores were significantly higher in patients who underwent the OL procedure using an SS technique vs. those in the ST group (91.6 ± 1.3 vs. 80.6 ± 25.5 [$P = .016$] and 91.8 ± 7.2 vs. 79.6 ± 16.1 [$P < .0001$], respectively). Meta-analysis subsequently found no significant differences in terms of postoperative ASES scores between the SS and ST groups ($P = .47$); however, the reported Constant scores were significant following meta-analysis ($P < .0001$). The meta-analysis performed in relation to postoperative Rowe, Constant, and ASES scores between the ST and SS groups is illustrated in Figure 2.

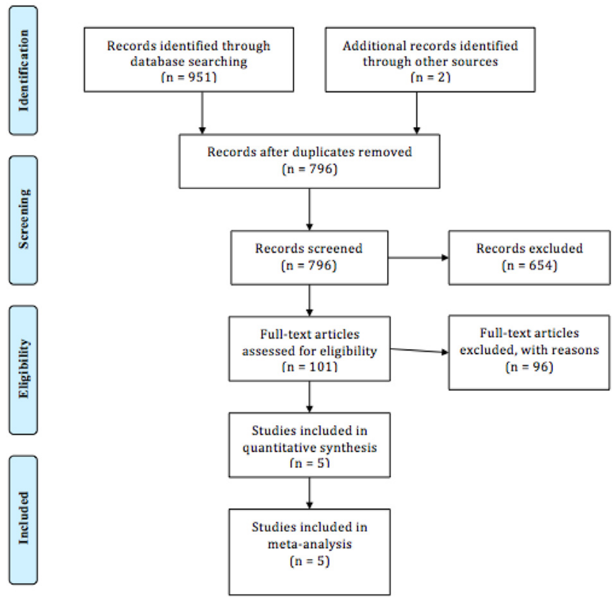


**Figure 1** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) flowchart.

At final follow-up, significantly more patients in the ST group had positive lift-off test results (10.0%) when compared with the SS group (2.7%, $P = .01$). A summary of demographic characteristics and clinical outcomes is presented in Table II. The meta-analysis performed in relation to postoperative lift-off test results between the ST and SS groups is illustrated in Figure 3.

## Discussion

The most important finding of this study was that although both the ST and SS techniques resulted in significant postoperative improvements in functional outcomes following the OL procedure via a DP approach, the SS technique resulted in significantly higher postoperative Rowe scores when compared with the ST technique. Furthermore, the use of the ST technique during the OL procedure resulted in significantly more patients having positive lift-off test results, suggesting that the SS technique results in superior subscapularis function in the medium term after the OL procedure.

As the most robust and powerful muscle of the rotator cuff, the subscapularis muscle acts as an active anterior stabilizer of the shoulder, particularly with respect to shoulder internal rotation, shoulder adduction and abduction, and humeral head depression.[13] During a change in

**Table I** Study characteristics

| Authors | LOE | Total patients, n | Male patients, n (%) | SS patients, n | ST patients, n | Age, yr | Follow-up, mo | Dominant hand, n | Previous ABR, n |
|---|---|---|---|---|---|---|---|---|---|
| Ersen et al,[5] 2018 | III | 48 | 42 (87.5) | 28 | 20 | 30 (16-69) | 25 (12-73) | 32 | 8 |
| Frantz et al,[6] 2020 | III | 65 | 59 (90.8) | 23 | 42 | 24.5 ± 8.2 | NR | 46 | 48 |
| Li and Jiang,[14] 2016 | III | 20 | 6 (30) | 5 | 15 | 55 ± 13 (26-79) | 31.6 (24-107) | NR | NR |
| Maynou et al,[15] 2005 | III | 106 | 90 (84.9) | 37 | 69 | 26.8 (15-51) | 90 (24-180) | NR | NR |
| Paladini et al,[16] 2012 | III | 376 | 300 (79.8) | 112 | 264 | 27 ± 5 | 43 (41-47) | NR | NR |

*LOE*, level of evidence; *SS*, subscapularis split; *ST*, subscapularis tenotomy; *ABR*, arthroscopic Bankart repair; *NR*, not reported.

position from internal to external rotation of the shoulder, the penetrating subscapularis nerve branches run close to the anterior border of the glenoid.[7] Therefore, careful management of the subscapularis muscle is warranted by the operating surgeon in approaching the glenoid, as the potential risk of rupture or denervation is greatest during this stage of the procedure, which could potentially result in poorer clinical outcomes after the OL procedure.[1] With respect to this, the optimal technique to minimize the aforementioned sequelae is of interest to shoulder specialists.

Concerns of recurrent instability are of utmost importance following the OL procedure, as subscapularis denervation remains an intraoperative concern in cases whereby both the SS and ST techniques are used by the operating surgeon. In a comparative study of patients with recurrent dislocation, Li and Jiang[14] found significantly higher rates of recurrent instability following the OL procedure when an ST technique was used for subscapularis management (53.3%) vs. an SS technique (0%). Thereafter, the authors suggested that the greatest success of the OL procedure is obtained in cases whereby an SS technique can be solely used by the operating surgeon. Despite this, our study found a nonsignificant difference in the rate of recurrent instability with the SS technique during the OL procedure, with an 11% recurrence rate reported in the ST group, in contrast to no recurrence in the SS group. Therefore, it is reasonable to speculate that further study on the topic may tip the balance toward significantly high rates of recurrent instability when an ST technique is used during the OL procedure via a DP approach.

In a respective cohort study, Scheibel et al[20] reported that the use of an L-shaped incision for ST during the OL procedure resulted in magnetic resonance imaging–confirmed fatty infiltration of the subscapularis. They concluded that this may compromise prospective clinical outcomes should the need for revision procedures using the same approach arise, owing to inferior muscle function and structure vs. when an SS technique is performed. However, in a prospective study of clinical outcomes after open Bankart repair (OBR), Sachs et al[18] found that approximately one-quarter of patients had positive lift-off test results when an SS technique was used. Additionally, they found that patient-reported satisfaction with their OBR procedure was positively correlated with clinical subscapularis function, that is, patients with negative lift-off test results in the short term were significantly more likely to report perceived excellent or good outcomes after OBR. With respect to this, our study found that management of the subscapularis during a DP approach for the OL procedure using the SS technique resulted in significantly lower rates of patients having clinically positive lift-off test results, suggesting subscapularis insufficiency, when compared with the ST technique as an alternative.

## Limitations

As this study is a systematic review of lower levels of evidence that is retrospective in nature, it inherently suffers from the innate limitations of the included studies themselves. Furthermore, the there was great heterogeneity in the data reported by the studies, with varying outcomes predominantly reported among the studies. Analysis of the data gathered for this study is also limited as a number of the studies included in this systematic review failed to report many of the outcomes of interest of our study. Therefore, not all included studies presented data that were appropriate for use in our meta-analysis. Moreover, when the random-effects model is applied to our meta-analysis in relation to postoperative Rowe scores, the overall impact of the heterogeneity as well as the robust findings of the 376 patients in the study by Paladini et al[16] is compensated for with respect to the findings of the study by Ersen et al,[5] which included only 48 patients. Therefore, the

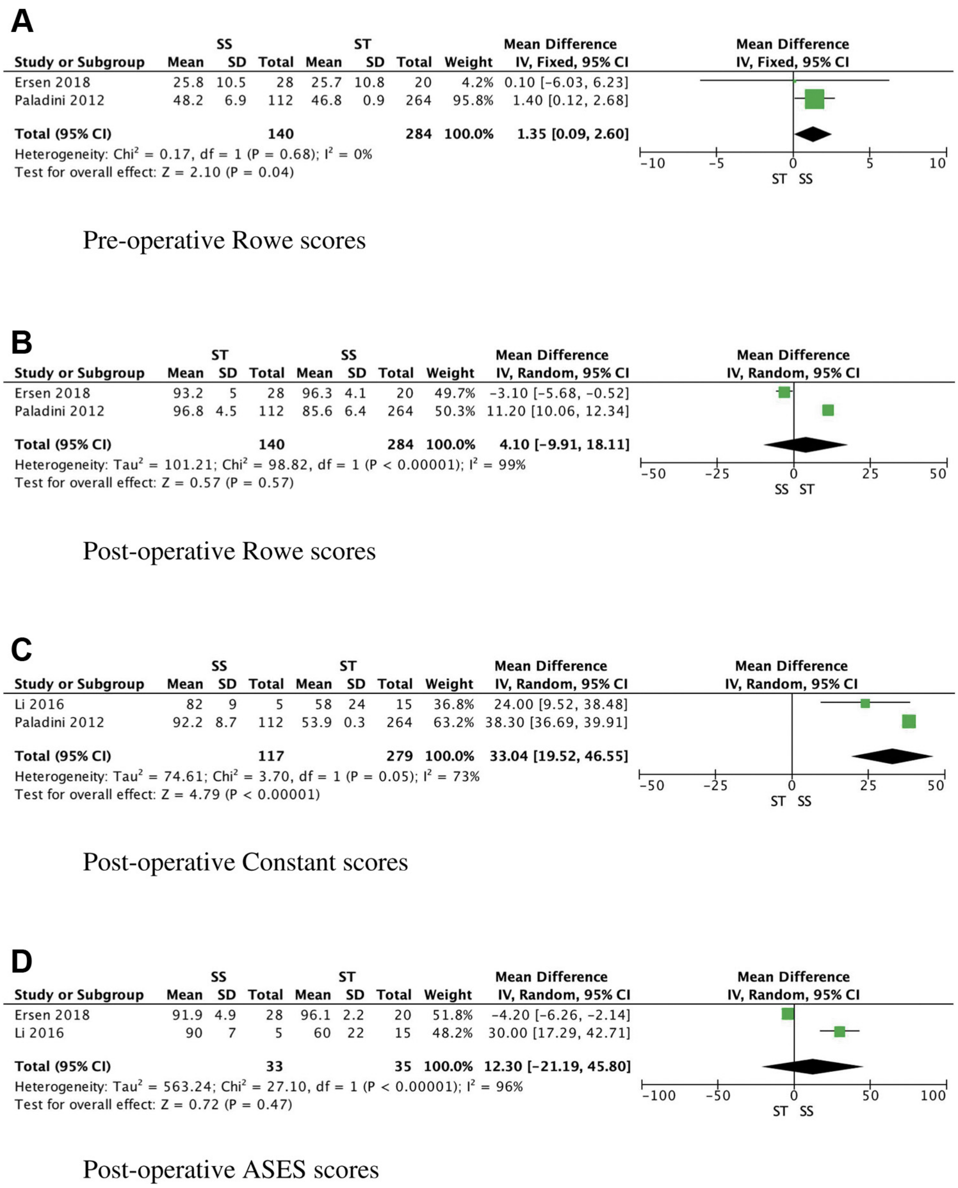


**Figure 2** Meta-analysis performed for clinical outcome measures between subscapularis tenotomy *(ST)* and subscapularis-split *(SS)* groups. (**A**) Preoperative Rowe scores. (**B**) Postoperative Rowe scores. (**C**) Postoperative Constant scores. (**D**) Postoperative American Shoulder and Elbow Surgeons scores. *SD*, standard deviation; *CI*, confidence interval.

robustness of these results may be brought into question on meta-analysis, when random-effects modeling has facilitated an almost 50-50 split in the weight of each study contributing to the forest plot results.

## Conclusion

Our systematic review established that in cases of OL procedures being carried out via a DP approach, the SS technique results in significantly better functional outcome measures and significantly lower rates of subscapularis insufficiency when compared with an L-shaped ST technique at medium-term follow-up. Furthermore, there were lower rates of recurrent instability that were trending toward significance in favor of the SS technique.

## Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: The authors, their immediate families, and any research foundations with which they are

**Table II** Demographic characteristics and clinical outcomes

| Variable | No. of studies | SS group | ST group | *P* value |
|---|---|---|---|---|
| Shoulders, n | 5 | 205 | 410 | NA |
| Male patients, n (%) | 5 | 157 of 182 (86.3%) | 306 of 368 (83.1%) | .386 |
| Age, yr | 3 | 27.2 ± 4.2 | 26.6 ± 3.9 | .0005* |
| Follow-up, mo | 3 | 41.9 ± 21.3 | 56.3 ± 34.1 | .0001* |
| Preoperative Rowe score | 2 | 43.7 ± 15.8 | 45.3 ± 14.9 | <.0001* |
| Postoperative Rowe score | 2 | 96.1 ± 2.5 | 86.4 ± 7.6 | .57 |
| Postoperative ASES score | 2 | 96.1 ± 1.3 | 80.6 ± 25.5 | .47 |
| Postoperative Constant score | 2 | 91.7 ± 7.2 | 79.6 ± 16.1 | <.0001* |
| Positive lift-off test result, n (%) | 2 | 4 of 149 (2.7%) | 33 of 331 (10%) | .01* |
| Recurrent instability, n | 3 | 0 of 56 | 9 of 77 | .01* |

*NA*, not applicable; *SS*, subscapularis split; *ST*, subscapularis tenotomy.
Data are presented as mean ± standard deviation unless otherwise indicated.
* Statistically significant difference between SS and ST groups.

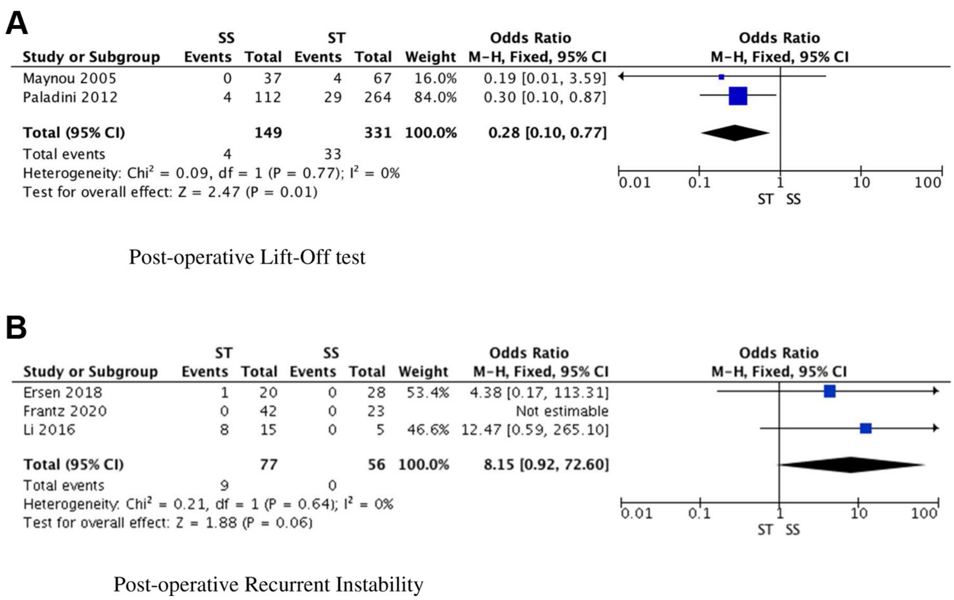


**Figure 3** Meta-analysis performed for postoperative lift-off test results (**A**) and recurrent instability (**B**) between subscapularis tenotomy *(ST)* and subscapularis-split *(SS)* groups. *CI*, confidence interval.

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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