

# Clinical Outcomes After Suture Tape Augmentation for Ankle Instability

## A Systematic Review

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**Background:** There is minimal literature on the use of suture tape augmentation in the treatment of chronic lateral ankle instability (CLAI), prompting an investigation on its use and effect during surgery of the lateral ankle.

**Purpose:** To evaluate the evidence for the use of suture tape augmentation in the treatment of CLAI and the outcomes after this procedure.

**Study Design:** Systematic review; Level of evidence, 4.

**Methods:** A literature search was performed using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Studies were included if they evaluated the use of suture tape for CLAI. Outcome measures included the Foot and Ankle Ability Measure, American Orthopaedic Foot and Ankle Society (AOFAS) score, return to play, and radiological improvement in anterior talar translation and talar tilt angle. Quantitative and qualitative analyses were performed.

**Results:** There were 11 studies (2 with level 2 evidence, 1 with level 3, and 8 with level 4) including 334 patients (334 ankles) that underwent suture-tape augmentation. The mean age was 27.3 years, 67.3% were women, and the mean follow-up was 27.6 months (range, 11.5–38.5 months). The mean weighted postoperative AOFAS score was 95, and 87.7% were able to return to sports. Overall, 9 recurrent instability events (4.1%) were reported. In 3 studies that compared Broström repair and suture tape augmentation, there were no significant differences between the procedures in recurrent instability (mean difference [MD], 0.81 [95% CI, 0.19 to 3.50];  $I^2 = 0\%$ ;  $P = .78$ ), Foot and Ankle Ability Measure (MD, 1.24 [95% CI, -3.73 to 6.21];  $I^2 = 66\%$ ;  $P = .63$ ), talar tilt angle improvement (MD, -0.07 [95% CI, -0.68 to 0.54];  $I^2 = 0\%$ ;  $P = .42$ ), or anterior talar translation improvement (MD, -0.06 [95% CI, -0.69 to 0.56];  $I^2 = 0\%$ ;  $P = .77$ ).

**Conclusion:** Suture tape augmentation did not significantly improve clinical or radiological outcomes in the setting of modified Broström repair for CLAI. There is currently insufficient evidence to recommend suture tape augmentation for all patients at this time.

**Keywords:** chronic lateral ankle instability; suture tape; ankle sprain; lateral ankle

Lateral ankle sprains continue to be the most common sports-related injury, with >27,000 sprains occurring per day in the United States alone.<sup>21,23</sup> Nonoperative management is adequate for the majority of patients, but for those cases that do not improve, chronic lateral ankle instability (CLAI) may require surgical intervention. Various surgical techniques have been used to treat CLAI, typically utilizing an open repair of the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) when required.<sup>3,21</sup> The Broström, Broström-Gould, and Karlsson procedures are all designed to repair the attenuated or torn ATFL.

These procedures have demonstrated good results over time; however, these operations are not without limitations. Concerns regarding lasting stability and strength of the repair, risk of reinjury, and time to return to sporting activity have inspired efforts to enhance and improve these surgical techniques.<sup>6</sup> As a result, minimally invasive procedures have garnered increased interest—specifically, an augmented technique utilizing suture tape as an internal brace to reinforce repairing ligaments.<sup>28</sup>

Initially, suture tape augmentation of the ATFL alone or the ATFL and CFL was recommended for patients with collagen disorders, ligamentous laxity, failed ligament repairs, and chronic instability.<sup>13,30</sup> Over time, this technique has become more mainstream and is now recommended for most patients with CLAI.<sup>6,12,13,19</sup> Various

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studies have indicated a mechanical superiority of an augmented ATFL reconstruction using suture tape, the purported benefit of earlier mobilization postoperatively, and a decreased risk of reinjury.<sup>4,13,26,30</sup> It has also been shown that after ligament augmentation using suture tape, return to play was faster than after the traditional repair.<sup>22</sup> Other studies have shown that open stabilization with augmentation resulted in fewer surgical revisions as compared with arthroscopic stabilization in CLAI.<sup>7</sup> Clinical and functional results of suture augmentation procedures have been excellent, but concerns about their overuse have come into question.<sup>15</sup> Performing suture tape augmentation when unnecessary may introduce otherwise avoidable complications to patients. Such complications include overtightening of the suture tape, subsequently altering the normal integrity of the ligament complex as well as restricting the motion of the subtalar joint.<sup>2</sup>

The purpose of the systematic review was to evaluate the evidence for the use of suture tape augmentation and the clinical outcomes after this technique in the setting of surgical repair for CLAI.

## METHODS

### Study Selection and Search Strategy

The literature search was performed by 2 authors (A.C.K. and A.P.S.) using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The following terms were used as the search algorithm in the MEDLINE, Embase, and Cochrane Library databases in May 2021: (internal brace OR suturetape OR suture tape OR fiber tape OR FiberTape) and (ankle OR instability OR ligament). The reference lists of all articles and relevant studies were screened for additional articles potentially not identified via our electronic search.<sup>16</sup> No time limit was given to publication date. Studies by the same author were reviewed to ensure that the patient cohorts were independent from one another. The search results were then reviewed with a senior author (J.G.K.) who arbitrated any disagreement. Duplicate studies were removed before screening and assessing study eligibility. The title and abstract identified in the search were screened, and potentially eligible studies received a full-text review.

### Eligibility Criteria

The inclusion criteria were as follows: clinical study on CLAI augmented with suture tape, publication in a peer-reviewed journal, and article in the English language. The

exclusion criteria were as follows: review studies, cadaver studies, biomechanical studies, abstract only, case reports, animal studies, and in vivo basic science studies.

### Data Extraction and Analysis

The relevant information regarding the study characteristics included the study design, level of evidence (LOE), methodological quality of evidence, population, clinical outcome measures, and follow-up time points. Data were collected by 2 blinded reviewers (N.P.M. and E.T.H.) using a predetermined data sheet, with the results compared by a third independent reviewer (A.P.S.).

The LOE was based on the previously published guidelines by the *Journal of Bone and Joint Surgery*.<sup>31</sup> The methodological quality of evidence was evaluated using a modified Coleman methodology score. Studies were considered excellent quality if they scored 85 to 100; good, 70 to 84; fair, 55 to 69; and poor, <55. Clinical outcomes extracted and analyzed were functional outcomes and return to sports, recurrent instability, revisions, instability arthropathy, and residual pain. When required information was not available in the text, the authors were contacted. Additionally, the MINORS (Methodological Index for Non-randomized Studies) was used to evaluate the potential assessed risk of bias for each study.<sup>24</sup> The items were scored 0 if not reported, 1 if reported inadequately, and 2 if reported adequately; the global ideal score was 16 for non-comparative studies and 24 for comparative studies.

### Statistical Analysis

Statistical analysis for comparative studies was performed using Review Manager (RevMan for Macintosh Version 5.3; Nordic Cochrane Centre, Cochrane Collaboration). Since LOE 2 and 3 studies have potential selection and performance bias based on their nonrandomized nature, we assessed the 3 comparative studies to ensure that authors minimized the risk of bias.<sup>3,27,32</sup> We quantified heterogeneity among studies using the  $I^2$  statistic.<sup>9</sup> We used an  $I^2$  value <25% to indicate low heterogeneity and >75% to indicate high heterogeneity. We used a fixed effects model when there was low heterogeneity and a random effects model if the heterogeneity was >50%. The method by Hozo et al<sup>9</sup> was used to calculate the standard deviation when the range was given. Results were presented in terms of risk ratio for dichotomous outcomes and mean difference (MD) for continuous outcomes, with a 95% confidence interval. A  $P$  value <.05 was considered to represent statistical significance.

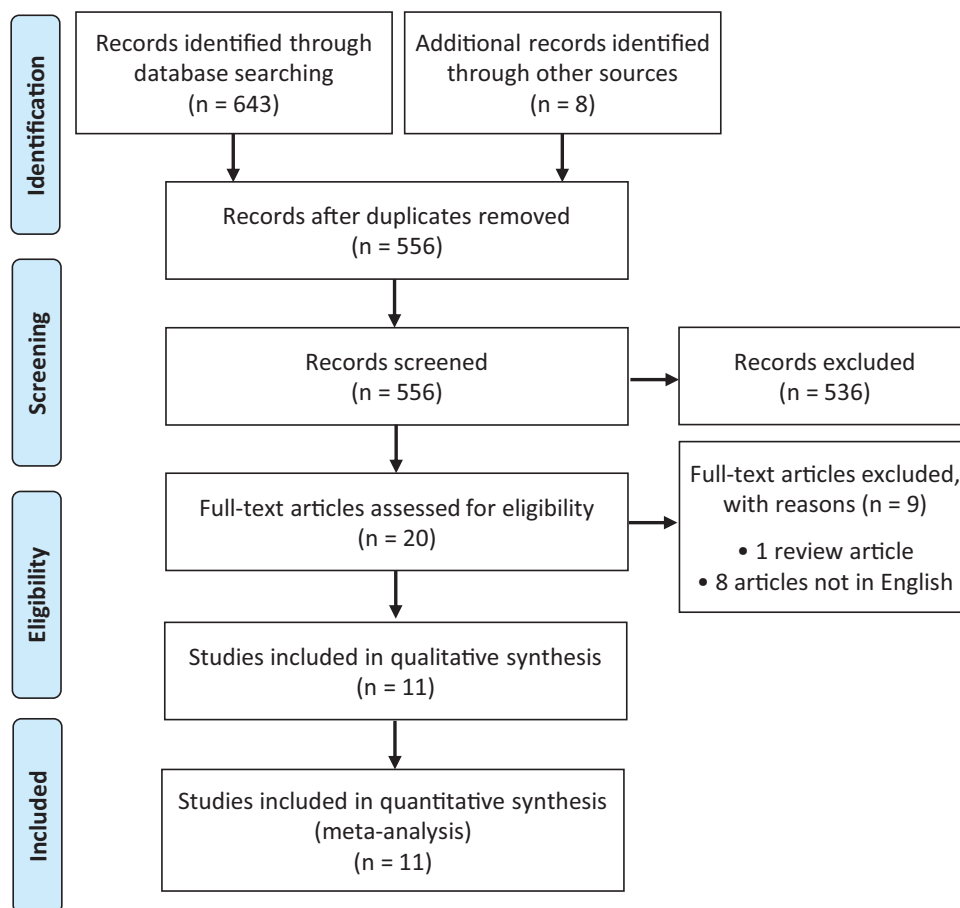
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**Figure 1.** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart of study selection.

Statistical analysis for the overall cohort of studies was performed using a commercially available statistical software package (SAS Version 9.3; SAS Institute). Descriptive statistics were calculated for each study, and parameters were analyzed. For each variable, the number and percentage of studies that reported the variable were calculated. Variables were reported as weighted mean and standard deviation where applicable.

## RESULTS

### Study Characteristics and Patient Characteristics

The search strategy yielded 643 studies, with 11 studies<sup>1-3,5-8,18,20,27,32</sup> ultimately meeting the inclusion criteria for review. A summary of our literature search is depicted in Figure 1.

All studies were published between 2015 and 2020. A total of 334 ankles had suture tape augmentation for CLAI, and 86 ankles underwent a modified Broström procedure in 3 studies<sup>3,27,32</sup> that compared both treatment modalities for patients with symptomatic CLAI. The mean age of patients was 27.3 years, with 66.7% being women. The mean follow-up was 27.6 months (range, 11.5-38.5 months). A summary of study characteristics and patient characteristics is

illustrated in Table 1, and the MINORS scores are shown in Table 2. Of the 11 studies, 5 reached the global ideal score for nonrandomized studies according to the MINORS criteria.<sup>1,5-7,20</sup> None of the 3 comparative studies met the global ideal score.<sup>3,27,32</sup>

### LOE and Methodological Quality of Evidence

There were 2 studies of LOE 2,<sup>3,27</sup> 1 study of LOE 3,<sup>8</sup> and 8 studies of LOE 4.<sup>1,2,5-7,18,20,32</sup> The mean  $\pm$  SD modified Coleman methodology score of all studies was  $57.1 \pm 12.3$  of 100 points. Only 2 studies<sup>3,27</sup> (18%) were classified as good quality using this score. Six studies<sup>2,5-8,32</sup> were of fair quality (55%), and 3 studies<sup>1,18,20</sup> (27%) were of poor quality. There were just 2 studies<sup>7,27</sup> investigating large numbers of patients ( $n > 60$ ).

### Clinical Outcomes

Several scores were used for the functional assessment, as shown in Table 3. The Foot and Ankle Ability Measure (FAAM) was the most common, with pre- and postoperative scores in 7 studies<sup>1-3,5,6,27,32</sup>; the weighted mean scores indicated improvement from 55.1 preoperatively to 90.2 postoperatively. Five studies<sup>2,3,5,6,27</sup> cited pre- and

TABLE 1  
Study Characteristics and Patient Characteristics<sup>a</sup>

| Study                              | LOE | Risk of Bias <sup>b</sup> | No. of Patients |          |             | Mean Age, y |             | Mean Follow-up, mo |             |
|------------------------------------|-----|---------------------------|-----------------|----------|-------------|-------------|-------------|--------------------|-------------|
|                                    |     |                           | All/Male        | Broström | Suture Tape | Broström    | Suture Tape | Broström           | Suture Tape |
| Cho (2015) <sup>5</sup>            | 4   | 16                        | 34/0            |          | 34          |             | 26.2        |                    | 31.4        |
| Cho (2017) <sup>6</sup>            | 4   | 16                        | 28/19           |          | 28          |             | 29.5        |                    | 35.8        |
| Ulku (2020) <sup>27</sup>          | 2   | 22                        | 61/—            | 31       | 30          | 28.6        | 27.8        | 36.8               | 35.9        |
| Cho (2017) <sup>2</sup>            | 4   | 12                        | 24/13           |          | 24          |             | 31.8        |                    | 38.5        |
| Coetzee (2018) <sup>7</sup>        | 4   | 16                        | 81/30           |          | 81          |             | 34          |                    | 11.5        |
| Mackay (2016) <sup>18</sup>        | 4   | 13                        | 20/5            |          | 20          |             | 31.6        |                    | 13          |
| Cho (2019) <sup>1</sup>            | 4   | 16                        | 24/9            |          | 24          |             | 29.2        |                    | 33.6        |
| Cho (2019) <sup>3</sup>            | 2   | 23                        | 55/0            | 27       | 28          | 28.1        | 26.6        | 33.8               | 34.6        |
| Xu (2019) <sup>32</sup>            | 4   | 21                        | 53/—            | 28       | 25          | 28.1        | 26.6        | 24                 | 24          |
| DeVries (2019) <sup>8</sup>        | 3   | 13                        | 12/6            |          | 12          |             | 39.5        |                    | 21          |
| Ramírez-Gómez (2020) <sup>20</sup> | 4   | 16                        | 28/18           |          | 28          |             | 33.3        |                    | 12.6        |

<sup>a</sup>Blank cells indicate data not reported. LOE, level of evidence. Dashes indicate not reported.

<sup>b</sup>See Table 2 for details.

TABLE 2  
MINORS Scores<sup>a</sup>

| Study                              | MINORS Item <sup>b</sup> |   |   |   |   |   |   |   |   |    |    |    | Total <sup>c</sup> |
|------------------------------------|--------------------------|---|---|---|---|---|---|---|---|----|----|----|--------------------|
|                                    | 1                        | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |                    |
| Cho (2015) <sup>5</sup>            | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 2  | 16                 |
| Cho (2017) <sup>6</sup>            | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 2  | 16                 |
| Ulku (2020) <sup>27</sup>          | 2                        | 2 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 2  | 2  | 2  | 22                 |
| Cho (2017) <sup>2</sup>            | 2                        | 0 | 0 | 2 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 2  | 12                 |
| Coetzee (2018) <sup>7</sup>        | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 2  | 16                 |
| Mackay (2016) <sup>18</sup>        | 1                        | 2 | 2 | 1 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 1  | 13                 |
| Cho (2019) <sup>1</sup>            | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 2  | 16                 |
| Cho (2019) <sup>3</sup>            | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2  | 2  | 2  | 23                 |
| Xu (2019) <sup>32</sup>            | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 2 | 2  | 2  | 2  | 21                 |
| DeVries (2019) <sup>8</sup>        | 2                        | 2 | 1 | 2 | 1 | 2 | 0 | 0 | 1 | 0  | 0  | 2  | 13                 |
| Ramírez-Gómez (2020) <sup>20</sup> | 2                        | 2 | 2 | 2 | 1 | 2 | 2 | 0 | 1 | 0  | 0  | 2  | 16                 |

<sup>a</sup>MINORS, Methodological Index for Nonrandomized Studies.

<sup>b</sup>(1) Clearly stated aim, (2) inclusion of consecutive patients, (3) prospective collection of data, (4) endpoints appropriate to the study aims, (5) unbiased assessment of the study endpoint, (6) follow-up period appropriate to the study aims, (7) loss to follow-up <5%, (8) prospective calculation of the study size. Additional criteria for comparative studies: (9) adequate control group, (10) contemporary groups, (11) baseline equivalence of groups, (12) adequate statistical analyses.

<sup>c</sup>The ideal score was 16 for noncomparative studies and 24 for comparative studies.

postoperative Foot and Ankle Outcome Score, with weighted means of 63.6 preoperatively and 91.1 postoperatively. Two studies<sup>20,32</sup> recorded pre- and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) scores, with a weighted mean improvement from 66.98 to 95.96. Three studies<sup>7,20,32</sup> reported postoperative AOFAS scores, with a weighted mean of 94.96. Visual analog scale scores for pain were obtained in 3 studies<sup>18,20,32</sup> and demonstrated improvement in weighted means from 5.27 to 0.73.

In the 3 comparative studies<sup>3,27,32</sup> of modified Broström repair versus suture tape augmentation, there was no significant difference in FAAM score (MD, 1.24 [95% CI, -3.73 to 6.21];  $I^2 = 66\%$ ;  $P = .05$ ). Clinical outcome data are shown in Figure 2.

## Functional Outcomes and Return to Play

Four studies reported return to play.<sup>5,7,8,18</sup> One study<sup>5</sup> utilized the Sefton grading system and indicated that 31 of 34 (91%) patients experienced excellent or good outcomes after suture tape augmentation, with a mean return to sports, defined as walking on uneven ground and jogging, of 9.6 and 10.2 weeks, respectively. One study<sup>7</sup> used the FAAM-Sports subscale, which showed a mean time to return to sports (68/81, 84.0%) of 84 days. One study<sup>8</sup> comparing Broström repair and open suture tape augmentation found that 9 of 12 patients who underwent suture tape augmentation returned to sports in a mean 170.7 days (range, 56-174 days). The last of the 4 studies commented only on

TABLE 3  
Clinical Outcomes for Suture Tape Augmentation and Modified Broström Repair<sup>a</sup>

| Study                              | FAAM        |            | FAOS        |            | AOFAS       |             | VAS for Pain |           |
|------------------------------------|-------------|------------|-------------|------------|-------------|-------------|--------------|-----------|
|                                    | Preop       | Postop     | Preop       | Postop     | Preop       | Postop      | Preop        | Postop    |
| Suture Tape <sup>b</sup>           |             |            |             |            |             |             |              |           |
| Cho (2015) <sup>5</sup>            | 56.2 ± 13.8 | 92.5 ± 6.1 | 63.1 ± 12.4 | 93.2 ± 6.5 |             |             |              |           |
| Cho (2017) <sup>6</sup>            | 54.3 ± 15.4 | 89.5 ± 6.7 | 63.2 ± 12.5 | 90.6 ± 5.2 |             |             |              |           |
| Ulku (2020) <sup>27</sup>          | 58.2 ± 16   | 93.3 ± 13  | 67.1 ± 11   | 91.5 ± 7.7 |             |             |              |           |
| Cho (2017) <sup>2</sup>            | 45.6 ± 14.8 | 85.1 ± 9.8 | 53.6 ± 16.1 | 87.5 ± 9.3 |             |             |              |           |
| Coetzee (2018) <sup>7</sup>        |             |            |             |            |             | 94.3 ± 9.3  |              | 0.8 ± 1.4 |
| Mackay (2016) <sup>18</sup>        |             |            |             |            |             |             | 3.1 ± 2.3    | 1.2 ± 2.3 |
| Cho (2019) <sup>1</sup>            | 53.5 ± 14.7 | 86.7 ± 9.3 |             |            |             |             |              |           |
| Cho (2019) <sup>3</sup>            | 58.3 ± 13.7 | 89.4 ± 7.4 | 69.5 ± 12.4 | 91.9 ± 6.7 |             |             |              |           |
| Xu (2019) <sup>32</sup>            | 58.2 ± 7.5  | 93.1 ± 12  |             |            |             |             |              |           |
| Ramírez-Gómez (2020) <sup>20</sup> |             |            |             |            | 68.2 ± 9.5  | 97.5 ± 3.3  | 6.2 ± 10.9   | 0.6 ± 0.7 |
|                                    |             |            |             |            | 65.9 ± 15.1 | 94.6 ± 6.88 | 6.0 ± 1.2    | 0.5 ± 0.9 |
| Modified Broström <sup>c</sup>     |             |            |             |            |             |             |              |           |
| Ulku (2020) <sup>27</sup>          | 58.7 ± 14   | 89.3 ± 15  | 66.2 ± 12   | 90.6 ± 5.2 |             |             |              |           |
| Cho (2019) <sup>3</sup>            | 57.2 ± 13.6 | 92.2 ± 6.5 | 70.2 ± 11.9 | 93.3 ± 6.1 |             |             |              |           |
| Xu (2019) <sup>32</sup>            | 58.9 ± 11.3 | 90.5 ± 5.1 |             |            | 67.3 ± 10.6 | 96.3 ± 6.0  | 6.4 ± 1.0    | 0.7 ± 1.2 |

<sup>a</sup>Blank cells indicate data not reported. AOFAS, American Orthopaedic Foot and Ankle Society; FAAM, Foot and Ankle Ability Measure; FAOS, Foot and Ankle Outcome Score; Postop, postoperative; Preop, preoperative; VAS, visual analog scale. Data reported as ± SD.

<sup>b</sup>Data not reported for DeVries (2019).<sup>8</sup>

<sup>c</sup>Data not reported for Cho (2015),<sup>5</sup> Cho (2017),<sup>6</sup> Cho (2017),<sup>2</sup> Coetzee (2018),<sup>7</sup> Mackay (2016),<sup>18</sup> Cho (2019),<sup>1</sup> DeVries (2019),<sup>8</sup> and Ramírez-Gómez (2020).<sup>20</sup>

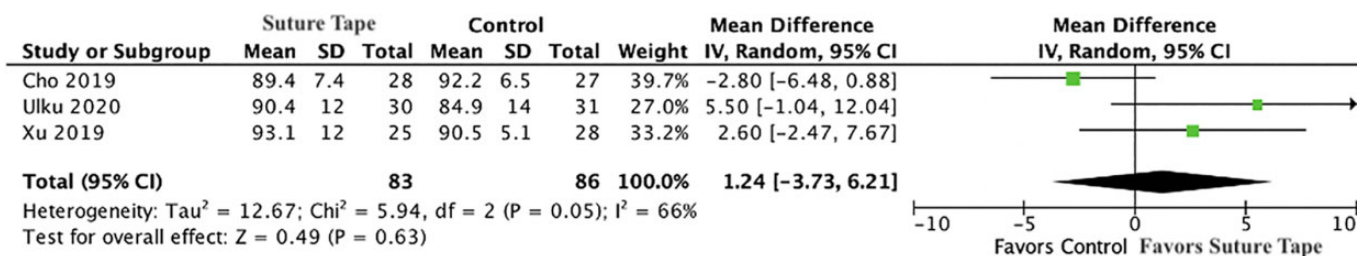


Figure 2. Fixed effects model for the Foot and Ankle Ability Measure score. IV, inverse variance.

patients deemed “sports oriented” when citing data regarding return to sports, showing that 20 of 20 patients who received suture tape augmentation returned to sports within 12 weeks.<sup>18</sup>

Radiological Findings

Six studies obtained measurement of anterior talar translation (ATT) pre- and postoperatively in patients who had suture tape augmentation, showing a mean weighted improvement of 12.87 to 4.04 mm (Table 4).<sup>2,3,5,6,27,32</sup> Three studies indicated measurement of the ATT values pre- and postoperatively in patients who underwent a modified Broström procedure only, showing a mean weighted improvement of 12.54 to 3.98 mm.<sup>3,27,32</sup> In the 3 comparative studies of modified Broström repair and suture tape augmentation, there was no significant difference in ATT

value improvement (MD, -0.06 [95% CI, -0.69 to 0.56]; I<sup>2</sup> = 0%; P = .77).<sup>3,27,32</sup> ATT radiological outcome data are shown in Figure 3.

Six studies<sup>2,3,5,6,27,32</sup> obtained measurement of the talar tilt angle (TTA) pre- and postoperatively in patients who had suture tape augmentation, showing a mean weighted improvement of 14.88° to 3.82° (Table 5). Three studies<sup>3,27,32</sup> indicated measurement of the TTA values pre- and postoperatively in patients who underwent a modified Broström procedure only, showing a mean weighted improvement of 13.88° to 3.80° with a mean follow-up of 31.7 months. In the 3 comparative studies, there was no significant difference in TTA value improvement (MD, -0.07 [95% CI, -0.68 to 0.54]; I<sup>2</sup> = 0%; P = .42) between modified Broström repair and suture tape augmentation.<sup>3,27,32</sup> TTA radiological outcome data are shown in Figure 4.



TABLE 4  
Radiological Findings: Anterior Talar Translation<sup>a</sup>

| Study <sup>b</sup>        | Suture Tape Augmentation |                   | Modified Broström Procedure |                   |
|---------------------------|--------------------------|-------------------|-----------------------------|-------------------|
|                           | Preoperative ATT         | Postoperative ATT | Preoperative ATT            | Postoperative ATT |
| Cho (2015) <sup>5</sup>   | 12.4 ± 5.1               | 4.1 ± 2.8         |                             |                   |
| Cho (2017) <sup>6</sup>   | 12.1 ± 5.5               | 4.2 ± 2.8         |                             |                   |
| Ulku (2020) <sup>27</sup> | 12.4 ± 13                | 4.3 ± 4.5         | 12.8 ± 12.4                 | 4.6 ± 4.1         |
| Cho (2017) <sup>2</sup>   | 12.4 ± 6.2               | 4.1 ± 2.5         |                             |                   |
| Cho (2019) <sup>3</sup>   | 12.8 ± 4.4               | 4.5 ± 2.3         | 12.6 ± 4.2                  | 4.2 ± 2.1         |
| Xu (2019) <sup>32</sup>   | 12.2 ± 3.6               | 2.9 ± 1.6         | 12.2 ± 3.9                  | 3.1 ± 1.3         |

<sup>a</sup>Values are presented in millimeters (mean ± SD). Blank cells indicate data not reported. ATT, anterior talar translation.

<sup>b</sup>Data not reported for Coetzee (2018),<sup>7</sup> Mackay (2016),<sup>18</sup> Cho (2019),<sup>1</sup> DeVries (2019),<sup>8</sup> and Ramírez-Gómez (2020).<sup>20</sup>

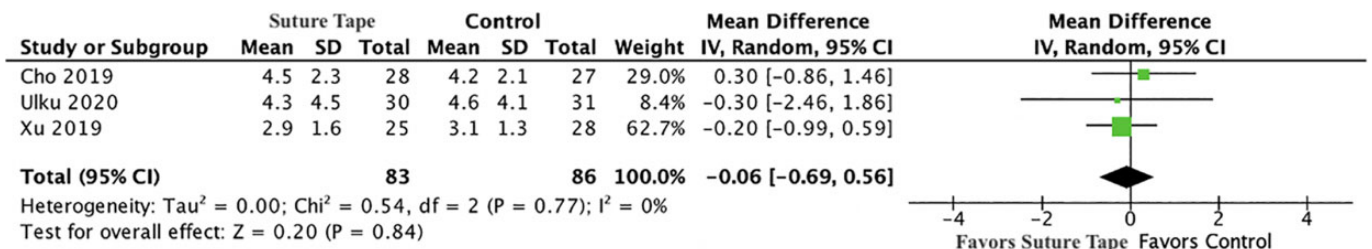


Figure 3. Fixed effects model for anterior talar translation. Cho 2019 refers to reference 3. IV, inverse variance.

TABLE 5  
Radiological Findings: Talar Tilt Angle<sup>a</sup>

| Study <sup>b</sup>        | Suture Tape Augmentation |                   | Modified Broström Procedure |                   |
|---------------------------|--------------------------|-------------------|-----------------------------|-------------------|
|                           | Preoperative TTA         | Postoperative TTA | Preoperative TTA            | Postoperative TTA |
| Cho (2015) <sup>5</sup>   | 16.3 ± 5.4               | 4.5 ± 3.5         |                             |                   |
| Cho (2017) <sup>6</sup>   | 16.2 ± 5.1               | 3.6 ± 2.2         |                             |                   |
| Ulku (2020) <sup>27</sup> | 13.8 ± 14                | 4.5 ± 4.4         | 13.4 ± 13                   | 4.7 ± 4.8         |
| Cho (2017) <sup>2</sup>   | 15.1 ± 6.5               | 2.8 ± 1.9         |                             |                   |
| Cho (2019) <sup>3</sup>   | 13.6 ± 5.2               | 4.6 ± 2.6         | 14.1 ± 5.4                  | 3.9 ± 2.3         |
| Xu (2019) <sup>32</sup>   | 14 ± 3.2                 | 2.4 ± 1.3         | 14.2 ± 3.5                  | 2.7 ± 1.4         |

<sup>a</sup>Values are presented in degrees (mean ± SD). Blank cells indicate data not reported. TTA, talar tilt angle.

<sup>b</sup>Data not reported for Coetzee (2018),<sup>7</sup> Mackay (2016),<sup>18</sup> Cho (2019),<sup>1</sup> DeVries (2019),<sup>8</sup> and Ramírez-Gómez (2020).<sup>20</sup>

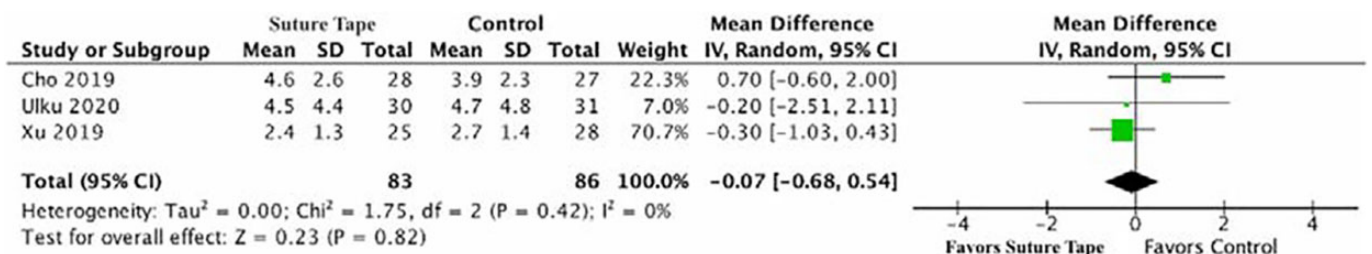


Figure 4. Fixed effects model for talar tilt angle. Cho 2019 refers to reference 3. IV, inverse variance.

### Recurrent Instability, Revisions, and Complications

In 8 of 11 studies,<sup>1,2,3,5-7,27,32</sup> there were 9 instances of recurrent instability in patients who received operative

treatment with suture tape augmentation, accounting for 3.3% (9/274) of patients (Table 6). In the 3 comparative studies between modified Broström repair and suture tape

augmentation, there was no significant difference in the number of recurrent instability events (MD, 0.81 [95% CI, 0.19-3.50];  $I^2 = 0\%$ ;  $P = .64$ ) (Figure 5).<sup>3,27,32</sup>

The rate of revisions, as reported in all 11 studies, indicated 5 patients who had revision surgery after suture tape augmentation (5/334, 1.5%). Complications were identified in 10 studies<sup>1-3,6-8,18,20,27,32</sup> for a rate of 9.7% (30/310) (Table 6). The type of complication varied among the studies but included superficial soft tissue infection, superficial peroneal nerve and sural nerve injury, skin irritation from the nonabsorbable suture, recurrence of lateral ankle instability, and immunological reaction to the suture tape itself.<sup>1-3,6-8,18,20,27,32</sup>

DISCUSSION

The most important finding from our study was that the use of suture tape augmentation for CLAI was not found to improve clinical outcomes as compared with anatomic ATFL repair alone, with no significant differences in rates of recurrent instability or complications. Of the 3 comparative studies that directly compared CLAI repair with and without suture tape augmentation in our review, there was no significant difference in clinical outcomes.<sup>3,27,32</sup>

Previous studies<sup>6,22</sup> have alluded to the favorable outcomes of suture tape augmentation in the athletic population, reporting accelerated rehabilitation as well as return to sports at a faster rate. Although some of the studies in our analysis indicated a fast return to play after suture tape augmentation, only 1 study directly compared suture tape augmentation with the arthroscopic Broström procedure.<sup>8</sup> Three studies in our analysis indicated a return to play of <12 weeks,<sup>5,7,17</sup> with 1 study citing a return to sports as early as 10.2 weeks.<sup>5</sup> However, DeVries et al<sup>8</sup> showed a significantly longer time to return to play in patients receiving suture tape augmentation (170.7 days) versus arthroscopic

Broström (127.2 days).<sup>20</sup> Two studies in our analysis appeared to report a large difference in return-to-sports times. DeVries et al indicated a mean return to play of 170 days, while Coetzee et al<sup>7</sup> cited a mean return time of 84 days. Of note with these 2 groups was that the cohort in the DeVries et al study consisted of 9 patients who underwent an open approach, while the cohort in Coetzee et al comprised 68 patients whose procedure was performed arthroscopically. Yet, certain studies have indicated that there may be an advantage in suture tape augmentation. Yoo and Yang noted that 18 patients (81.8%) in the suture tape group returned-to-sports activity without limitations, whereas only 17 patients (27%) in the Broström group were able to do so at 12 weeks after surgery.<sup>33</sup>

In a retrospective series, Lee et al<sup>14</sup> evaluated return-to-sports time in elite athletes after a modified Broström repair for CLAI, and more than half of their patient cohort indicated a “late return to sports” at a mean  $4.8 \pm 1.3$  months. Additionally, in a systematic review of 20 articles evaluating 489 athletes who underwent surgical treatment for ankle instability, a weighted mean time to return to play was 4.7 months.<sup>10</sup> Although there are limited data directly comparing return-to-play time in suture tape augmentation versus traditional Broström repair, current data appear to suggest that suture tape augmentation may allow for faster return to play. However, given the small number of studies evaluating return to play in our analysis and the limited comparative studies in the literature, future high-quality studies are needed to confirm faster return to play for patients with suture tape augmentation.

One potential drawback of suture tape augmentation is the risk of overconstraint and stiffness. Cho et al<sup>2</sup> and Xu et al<sup>32</sup> found no difference in pre- and postoperative range of motion with the use of suture tape augmentation. Yet, Coetzee et al<sup>7</sup> noted significantly decreased dorsiflexion with the use of suture tape augmentation, though they indicated that these patients still had excellent dorsiflexion, comparable to 88.5% of the contralateral ankle. While overconstraint is also a risk with native ligament repair, suture tape may not have the same potential to stretch or creep as native ligament<sup>10,11</sup> and thus may be more likely to cause persistent overconstraint and stiffness postoperatively. In many sporting activities, flexibility of the subtalar and ankle joints is critical; therefore, a hard end point to dynamic motion may not be advantageous. While overtightening was a potential problem in the first-generation

TABLE 6  
Recurrent Instability, Complications, and Revision Surgery After Suture Tape Augmentation

| Outcome          | No. of Studies | No. (%)      |
|------------------|----------------|--------------|
| Total recurrence | 8              | 9/274 (4.1)  |
| Complications    | 10             | 30/310 (9.7) |
| Revision surgery | 11             | 5/334 (1.5)  |

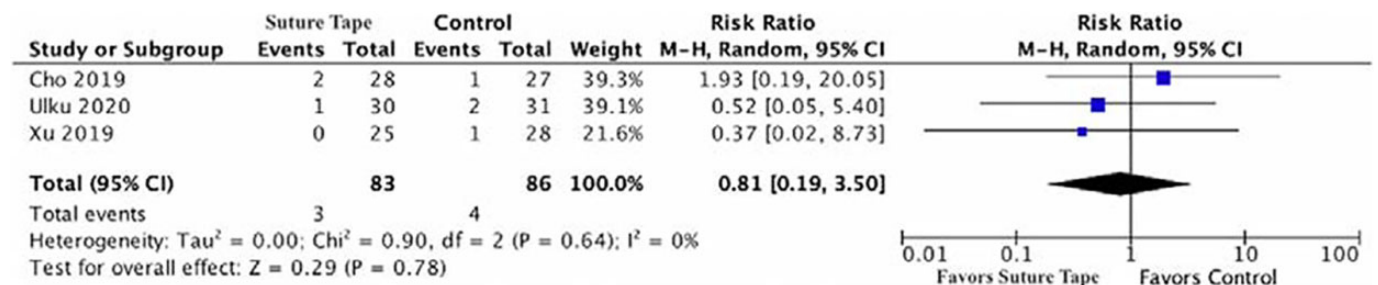


Figure 5. Fixed effects model for recurrent instability events. Cho 2019 refers to reference 3. M-H, Mantel-Haenzel.

suture tape, this issue has been recognized and can now be anticipated and prevented at the time of surgery by testing ankle and subtalar range of motion before final anchor placement and making sure to hold the tape in the optimal biomechanical position.

There were no significant differences in radiographic outcomes between modified Broström repair with and without suture tape augmentation. These outcomes were expected because the suture tape was used to augment the anatomic ligament repair and utilize the anatomic footprint of the ATFL.<sup>7,29</sup> Therefore, at an early time point, no radiographic changes would be expected. Long-term posttraumatic osteoarthritis, however, may be prevented or, in some measure, augmented via overtightening of the ligaments, and long-term studies are required to determine whether the suture tape has a role in arthritic changes in the hindfoot.

The radiographic measurements in these studies were designed to evaluate static stability. Suture tape augmentation and the modified Broström repair compared favorably, as expected. It is important to mention that TTA is correlated but not exclusively related to ATFL laxity and more strongly correlated to CFL integrity.<sup>25</sup> Standard practice with suture tape implementation is to augment the ATFL repair but not necessarily the CFL repair.<sup>18</sup> In our study, several articles stated their methodology of repair in their surgical technique, which included either ATFL only or ATFL with CFL repair.<sup>1-3,5-7,20,32,27</sup> Twenty-eight percent (95/334) of patients in this study received suture repair augmentation of the ATFL only, while 60% (201/334) received augmentation of the ATFL and CFL. To better evaluate dynamic stability of the repair, however, the use of anterior drawer and talar tilt using a telos device may be of greater benefit. This would be an interesting finding, yet this was not seen in the current studies that we evaluated. Future studies will be valuable to determine whether suture tape augmentation improves initial dynamic stability and whether this stability remains constant or elongates over time, as would native ATFL.

Several clinical questions warrant further study on the use of suture tape for CLAI. Given prior findings, the most common method of failure after suture tape augmentation is talar suture anchor pullout.<sup>29</sup> Therefore, future studies are needed to evaluate whether low bone mineral density is a contraindication to the use of suture tape augmentation. While Schuh et al<sup>22</sup> found that bone mineral density in cadaveric specimens did not significantly affect the strength of suture tape-augmented ATFL repair, this has not yet been borne out in clinical studies in human subjects.<sup>20</sup>

The current study has revealed that suture tape-augmented ATFL repair is an excellent procedure, but it has not defined the specific cases in which this technique would have a clear benefit over traditional ATFL repair. The clinical and economic benefits of suture tape augmentation in the general population have yet to be defined.<sup>26</sup> There may also be a role for suture tape augmentation in revision cases with recurrent CLAI where the quality of the native tissue is of poorer quality. In a similar fashion, patients with collagen disorders and inadequate native tissue would clearly

benefit from suture tape augmentation. For these patients, the current study has shown fair evidence for the use of the suture tape augmentation to maintain a B grade of recommendation. Beyond these cohorts, there appears to be less benefit over traditional repair techniques, and the grade of recommendation for the use of suture tape is insufficient at this time to warrant higher than a grade C of recommendation.

## Limitations

There were several limitations to this study, such as the quantity and quality of studies in this review. The majority of the studies were retrospective, had low sample sizes, and were heterogenous in their outcomes, which limits the strength of our conclusions. Of the 11 studies, the overall LOE was considered fair. There were no LOE 1 studies in this systematic review. The methodological quality overall was considered poor. Six studies were of fair methodological quality, and 3 were of poor methodological quality.<sup>1,18,20</sup> Although 5 of 11 studies met the global ideal score for non-randomized studies according to the MINORS scoring criteria, the majority of studies were nonrandomized and comparative, which may still have increased the risk of selection bias.<sup>1,5-7,20</sup> The absence of high-level quality evidence in this systematic review makes it difficult to make clinical recommendations; therefore, the results of this review should be analyzed with caution. Only 3 studies<sup>3,27,32</sup> in this review directly compared modified Broström repair with and without suture tape augmentation; this highlights the need for prospective randomized controlled trials and comparative studies. The statistical power in some of the outcome measures may also be underpowered to detect a significant difference. Although our study showed no difference in the rate of recurrent instability between procedures, this lack of a difference could be due to the meta-analysis being underpowered to detect a difference.

## CONCLUSION

Suture tape augmentation did not significantly improve clinical or radiological outcomes in the setting of modified Broström repair for CLAI. There is currently insufficient evidence to recommend suture tape augmentation for all patients at this time.

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