Systematic Review

Suture button fixation yields high levels of patient reported outcomes, return to sport, and stable fixation in isolated Lisfranc injuries: A systematic review

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ABSTRACT

Importance: Lisfranc injuries remain a significant, but often misdiagnosed, orthopaedic injury. Alongside the traditional methods of surgical fixation, including arthrodesis and open reduction and internal fixation with screws, suture button fixation is an emerging technique.

Objectives: The purpose of this study is to investigate the efficacy of suture button fixation for treatment of Lisfranc injuries through a systematic review.

Evidence review: A comprehensive literature review was conducted according to the preferred reporting items for systematic reviews using PubMed, Embase, Web of Science, and Cochrane databases for original, English-language studies observing outcomes of Lisfranc injury until August 19, 2022. The clinical studies with evidence level I–IV and at least a 12 month follow-up after the index surgery were included if they examined quantifiable outcomes of Lisfranc injury treated with suture button. Articles were excluded if they included case reports, systematic reviews, comments, editorials, surveys, animal studies, or biomechanical/cadaveric studies. Variables extracted from text and figures include demographic information, return to sport measures, patient reported outcomes, and complications.

Findings: Of the 10 studies included, there were 186 total patients with an age range of 13–72. In every study, all patients were able to return to sport or activity with a return time averaging from 10.8 to 25.9 weeks. Postoperative American Orthopaedic Foot and Ankle Society scores ranged from 83.5 to 97.0 while pain Visual Analogue Scale ranged from 0.6 to 2.5. Complications were reported in four studies at a rate of 7.7% including two cases of diastasis, two cases of paraesthesia, one case of button irritation, and one of postoperative degenerative joint disease, with no reported revisions.

Conclusions and relevance: In our systematic review, suture button fixation shows high levels of patient reported outcomes, return to sport, and stable fixation in isolated Lisfranc injuries. This surgical technique provides a physiologic reduction across the Lisfranc joint and reduces the need for reoperation including removal of hardware. However, further evidence such as large sample size high-quality randomized controlled trials is needed to draw a definitive conclusion regarding the best treatment for Lisfranc injuries.

Level of evidence: Level IV, Systematic Review of Level III and IV studies.

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What is already known?

- Suture button fixation is an emerging technique for the fixation of Lisfranc injuries.
- Similar to syndesmotic fixation, suture button fixation may allow an anatomic reduction with flexible fixation.

What are the new findings?

- Across 10 studies, there were high rates of return to sport/activity, high patient reported outcomes, and low complication rates.
- Further large sample size high-quality randomized controlled trial (RCT) studies are required to compare outcomes of suture button Lisfranc fixation to open reduction and internal fixation (ORIF) or arthrodesis.

Introduction

Lisfranc injuries can be sustained through a variety of low and high energy mechanisms resulting in purely ligamentous injury or a fracture with an avulsed piece of bone [1]. While Lisfranc injuries only make up about 0.2% of orthopaedic trauma injuries [2], it can be misdiagnosed up to 40% of the time due to the subtle nature of these injuries [3,4]. As a keystone of the foot arch, Lisfranc joint injury is essential to diagnose and manage appropriately to prevent diastasis between the medial and middle columns, chronic pain, arthritis, and even midfoot collapse [5].

Previous studies have largely compared rigid fixation constructs for Lisfranc injuries, including arthrodesis and ORIF with screws, plates, and k wires. While studies have been inconclusive of favourability of arthrodesis vs ORIF [6,7], there is significant risk for screw complications and need for hardware removal with plate and screw constructs [6,8,9]. Recently, flexible fixation, including suture buttons, has been used as a means of fixation for these injuries. Cortical button fixation has shown great success in treatment of distal biceps injury, Anterior Cruciate Ligament (ACL) and AcromioClavicular (AC) joint dislocations due to its high load to failure [10]. Suture button has emerged as an alternative mechanism to achieve and maintain anatomic reduction of Lisfranc injuries [11]. Some studies have suggested that suture buttons allow for motion within the midfoot, similar to tibiofibular motion when used for syndesmotic fixation [12]. The flexibility of non-absorbable suture is suspected to decrease stiffness postoperatively and may lead to appropriate tension across the Lisfranc joint [13,14]. While several studies have reviewed the outcomes of Lisfranc injuries utilizing plate, screw, and k wire constructs for arthrodesis or ORIF [6,15,16], there has yet to be a review of the literature focusing on suture button fixation outcomes of Lisfranc injuries.

With this purpose in mind, we performed a systematic review to access outcomes of Lisfranc injuries with suture button fixation. Based on the existing literature and utilization of the cortical button in other orthopaedic injuries, we hypothesized that suture button fixation for Lisfranc injuries yielded improved clinical, functional, and radiological outcomes.

Materials and methods

Literature search strategy

A comprehensive literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) using the PubMed, Embase, Web of Science, and Cochrane databases for all articles. This combination search strategy employed the following keywords ((Lisfranc OR Midfoot OR Tarsometatarsal) AND (Injury OR Instability OR Fracture OR Dislocation)) AND (ORIF OR Fixation OR Reconstruction OR suture* OR button* OR Fiber*). The most recent search was performed on August 19, 2022. Additionally, the references of each included study were reviewed for additional publications that were not captured in the initial database search. Eligible articles were deemed as those published in English before August 19, 2022. Two independent librarians assisted to check the search strategy for errors.

Study selection

The titles and abstracts of all resulting articles were independently investigated by two authors (M.E.G., and A.D.L.) to determine relevancy to suture button fixation following Lisfranc injury. The third and fourth reviewers (A.E., and W.L.) were consulted in the case of any disagreement. The final decision for the study selection was reached based on group consensus. Following the initial title and abstract screening, the remaining studies were meticulously reviewed by each author utilizing the following inclusion criteria: clinical trials, RCTs, and cohort studies that examined quantifiable outcomes of Lisfranc injury treated with suture button, clinical studies with evidence level I–IV and that averaged at least a 12 month follow-up after the index surgery. Articles that met each of these criteria were included in the systematic review. Articles were excluded if they included case reports, systematic reviews, comments, editorials, surveys, animal studies, or biomechanical/cadaveric studies.

Data collection outcome measures

Patient demographics including age and sex, study data (authors, year of publication, level of evidence, study design, and number of patients), aetiology of Lisfranc injury, mechanism of injury (sports related vs. non-sports related), mean follow-up times, and time to surgery were extracted for each study. Clinical outcomes included preoperative and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) score, preoperative and postoperative Visual Analogue Scale (VAS) for pain, and radiographic outcomes such as diastasis. Return to sports/duty and activity and time to return were extracted from each article. Postoperative complications were also recorded. Data collection was performed by two independent co-authors, and the third and fourth authors were consulted in the case of disagreement.

Study quality assessment

The quality of all included studies in this review was evaluated by the modified Coleman Methodology Score by two independent co-authors. The modified Coleman Methodology Score assess methodology of studies on a 0–100 scale in which a score of 100 indicates minimal chance, bias, and confounding factors (Table 1) [17,18]. The third reviewer (W.L.) was consulted if there was any disagreement (Table 2).

Statistical analysis

Weighted means and standard deviation were calculated for the patients’ age, follow-up period, AOFAS score, VAS pain score, and preoperative/postoperative diastasis on radiograph utilizing Excel Version 16.66.1. Patients from Chun et al. [19] were excluded from the weighted average, return to activity rate/time, and the complication rate as there were overlapped patients between their study and the study in Cho et al. [11].

Results

Included studies

Our initial search found 2297 studies that were potentially relevant (Fig. 1). Duplicates of studies found in multiple databases were excluded, leaving 1349 unique entries. The title and abstract of the remaining studies were reviewed, leaving 40 studies to be further evaluated. After filtering out case reports, review articles, technique articles, and studies
without results for suture-button fixation, 10 studies were ultimately included in the final analysis. The data were screened in accordance with the “PRISMA” system.

Study characteristics

All included studies were retrospective in nature (Table 3). There were no level I or level II studies. Three of the studies were level III studies while seven were level IV.

Demographics

Of the 10 studies included, there were 186 total patients, age ranged from 13 to 72 years old, 60.3% were male and time to surgery ranged from 4.5 days to 6 months [11,13,19–26]. Average age was 36.0 years old ±7.1. Studies had follow-up of greater than 1 year ranging from 12 months to 42 months, with all 10 studies having 100% follow-up because all studies had inclusion criteria that dictated a minimum time for follow-up [11,13,19–26]. Average follow-up was 34.0 months ±2.6. Of the 74 patients whose mechanism of injury was known, 63 of them (85.1%) were due to sports-related trauma. Five of the studies analysed acute isolated Lisfranc injuries [11,13,19–24], while one looked at chronic Lisfranc injuries [21]. Time to surgery was reported in five studies [11,19–21,24], and most patients (60 out of 73) underwent surgery within two weeks after initial evaluation [11,19,20,24], with one study having time to surgery greater than 6 months post-injury [21] (Table 3). Compared to groups utilizing screw fixation, Cho et al. had 21 out of 32 patients who were male, with an average age of 37.9 and underwent surgery at an average of 5.8 days [11]. Patient undergoing screw fixation in Gee et al. [25] had 5 out of 6 patients that were male with an average age of 25.7.

Functional outcomes

AOFAS scores were reported in seven studies [11,13,19–23] and VAS scores were reported in five studies [11,13,20,22,25]. The preoperative AOFAS score ranged from 30.96 to 66.17, averaging 36.5 ± 9.3, while preoperative VAS ranged from 7.1 to 8.4, averaging 8.2 ± 0.4. The postoperative AOFAS score was 83.5–97, averaging 89.6 ± 3.5, while the postoperative VAS score was 0.6–2.5, averaging 1.6 ± 0.5 (Table 4). Charlton et al. [21] found AOFAS increased from 65 to 97 post-operatively. Patients from Cho et al. [11] found improved AOFAS scores from 45.1 to 83.5 and VAS of 7.9–2.5 postoperatively. Additionally, Cottom et al. [13] found improvements in AOFAS of 30.96–90.3 post-operatively and VAS improved from 8.4 to 1.3. Postoperatively, Crates et al. [23] found an AOFAS of 92 among 12 patients while Gee et al. [25] found an AOFAS of 92 among 12 patients while Gee et al. [25] found AOFAS scores ranging from 30.96 to 66.17, averaging 36.5 ± 9.3. However, at 1-year, there was not a significant difference in AOFAS and VAS scores between the two types of fixations. The second study [25] showed that there was no significant difference between suture button fixation and screw fixation in terms of postoperative AOFAS score, complication rate, or time to return to full duty.
<table>
<thead>
<tr>
<th>Authors &amp; Publication Year</th>
<th>Study Size (10)</th>
<th>Mean Follow-up (10)</th>
<th>Surgical Approach (10)</th>
<th>Type of study (15)</th>
<th>Description of Diagnosis (5)</th>
<th>Descriptions of surgical technique (10)</th>
<th>Description of post-intervention rehabilitation (5)</th>
<th>Outcome criteria (10)</th>
<th>Procedure for assessing outcomes (15)</th>
<th>Description of subject selection process (5)</th>
<th>Total score (100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton T; Boe C et al. 2015</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>59</td>
</tr>
<tr>
<td>Cho J; Kim J et al. 2021</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>60</td>
</tr>
<tr>
<td>Chun Di; Kim J et al. 2021</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>54</td>
</tr>
<tr>
<td>Cotton JM; Granev CT et al. 2020</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Crates, JM; Barber, FA 2012</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>54</td>
</tr>
<tr>
<td>Gee, S; Harris, MC et al. 2019</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Jain K; Drampalos E et al. 2017</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>59</td>
</tr>
<tr>
<td>Saxena, A; Shou L et al. 2021</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>7</td>
<td>10</td>
<td>5</td>
<td>48</td>
</tr>
<tr>
<td>Sullivan, M; Peckston, D et al., 2022</td>
<td>0</td>
<td>7</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>7</td>
<td>10</td>
<td>5</td>
<td>59</td>
</tr>
<tr>
<td>Yongfei F; Chaoyu L et al. 2021</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>54</td>
</tr>
</tbody>
</table>
Radiographic outcomes: diastasis

Preoperative diastasis averaged 4.0 mm $\pm$ 1.6 [11,13,19,20,25]. Postoperative diastasis distance was reported in five studies [11,13,19–21], averaging 0.8 mm $\pm$ 1.1. Postoperative diastasis ranged from 0.14 mm [19] to 1.9 mm [20]. Yongfei et al. [20] found diastasis to decrease from an average of 8.9 mm to 1.9 mm at the last postoperative visit. Alternatively, Chun et al. [19] found preoperative diastasis of 2.91 mm decreased to 0.14 mm postoperatively. Diastasis in 31 patients in Cho et al. [11] decreased from 4.6 mm to 2.5 mm postoperatively. Cotton et al. [13] reported diastasis decreased from 3.15 mm to an average of 0.43 mm at the last follow-up appointment. Another study found all patients had less than 1 mm of diastasis at the Lisfranc joint directly postoperatively but did not report long-term outcomes [21].

Return to sport/activity

Return to activity was reported in eight studies [11,19–22,24–26]. Among them, the study from Chun et al. [19] was not included as there were patients overlapped with the study in Cho et al. [11]. In those studies, all patients who underwent suture-button fixation were able to return to their respective sports, and return to activity ranged from 10.8 weeks to 25.9 weeks (Table 5). In a study of high-level athletes participating in rugby (7), dancing (2), gymnastics (1), and wakeboarding (1), all athletes returned to training at an average of 10.8 weeks with return to full competition averaging 13.8 weeks [24]. In a series of three runners, two soccer players, and one volleyball player, Saxena et al. [26] found a return to sport at an average of 27 weeks. Five soccer and rugby players in the English Premier League returned to training at 16.1 weeks and full competition at 20.4 weeks [22]. Within the military population, all patients returned to full duty at an average of 181 days vs only 50% of patients undergoing screw fixation at an average of 358 days [25]. Charlton et al. [21] allowed professional dancers or division one athletes to return to sport at 6 months and reported all patients returned to full activity with no residual deficit by 6 months. Yongfei et al. [20] found patients returned to walking with full weight bearing and almost full activity at 3 months. Among 31 patients, Cho et al. found to return to sports practice took 12–16 weeks postoperatively [11].

Revisions and complications

Among this pooled patient population, complications following suture button fixation for Lisfranc injury were reported in 7.7 percent of patients. However, there were no reports of revisions in any of the suture-button cohorts in all studies (Table 6). Four studies reported complications in their cohorts [11,22,24,26]. One study from Cho et al. reported recurrent Lisfranc joint diastasis in 2 patients out of the 31 who underwent suture button fixation after tensioning of a subsided round button at the medial cuneiform [11]. Nevertheless, in 31 patients who underwent screw fixation in the same study, 2 cases of early arthritic change, 4 cases of screw breakage, and 1 case of recurrent diastasis were reported. Another study by Jain et al. reported one case out of five patients with transient deep peroneal nerve sensation change without a need for implant removal [22]. Sullivan et al. reported one case out of 12 patients...
<table>
<thead>
<tr>
<th>Authors &amp; Publication Year</th>
<th>Level of evidence</th>
<th>Study Design</th>
<th>Type of Lisfranc injury</th>
<th>Sex (M:F)</th>
<th>Age (years)</th>
<th>Mechanism (# and % sports-related)</th>
<th>Follow up (Months)</th>
<th>Time to surgery</th>
<th>Coleman Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton T; Boe C et al. 2015</td>
<td>4</td>
<td>Retrospective case series</td>
<td>Chronic Lisfranc injury</td>
<td>1: 6</td>
<td>24.6</td>
<td>7/7 (100%)</td>
<td>25</td>
<td>&gt;6 months</td>
<td>57</td>
</tr>
<tr>
<td>Cho J; Kim J et al. 2021</td>
<td>3</td>
<td>Retrospective case control</td>
<td>Isolated Lisfranc ligament injuries</td>
<td>18: 13</td>
<td>40.9</td>
<td>15/31 (48%)</td>
<td>&gt;12</td>
<td>6.2 ± 2.16 days</td>
<td>58</td>
</tr>
<tr>
<td>Chun Di; Kim J et al. 2021</td>
<td>4</td>
<td>Retrospective case series</td>
<td>Isolated Lisfranc ligament injuries</td>
<td>7: 5</td>
<td>31.6</td>
<td>NR</td>
<td>&gt;12</td>
<td>8 of 12: &lt;1 week 2 of 12: 3 weeks 1 of 12: 8 weeks 1 of 12: 12 weeks</td>
<td>57</td>
</tr>
<tr>
<td>Cotton JM; Grane CT et al. 2020</td>
<td>4</td>
<td>Retrospective cohort</td>
<td>Isolated Lisfranc ligament injuries</td>
<td>50: 34</td>
<td>39.7</td>
<td>NR</td>
<td>40.8</td>
<td>NR</td>
<td>62</td>
</tr>
<tr>
<td>Crates, JM.; Barber, FA 2012</td>
<td>4</td>
<td>Retrospective case series</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>57</td>
</tr>
<tr>
<td>Gee, S; Harris, MC et al. 2019</td>
<td>3</td>
<td>Retrospective case control</td>
<td>Primarily ligamentous Lisfranc injuries</td>
<td>5: 1</td>
<td>29.7</td>
<td>6/11 (54.5%)</td>
<td>12.4</td>
<td>NR</td>
<td>49</td>
</tr>
<tr>
<td>Jain K; Drumpalos E et al. 2017</td>
<td>4</td>
<td>Retrospective case series</td>
<td>Unstable and displaced ligamentous Lisfranc injuries</td>
<td>5: 0</td>
<td>22.1</td>
<td>5/5 (100%)</td>
<td>24</td>
<td>NR</td>
<td>57</td>
</tr>
<tr>
<td>Saxena, A; Shou L et al. 2021</td>
<td>4</td>
<td>Retrospective case series</td>
<td>Acute (&lt;6 weeks) Lisfranc ligament injury</td>
<td>2: 4</td>
<td>20.6</td>
<td>7/7 (100%)</td>
<td>19.4</td>
<td>NR</td>
<td>54</td>
</tr>
<tr>
<td>Sullivan, M; Peckston, D et al. 2022</td>
<td>4</td>
<td>Retrospective case series</td>
<td>Isolated Lisfranc ligament</td>
<td>9: 3</td>
<td>21.1</td>
<td>12/12 (100%)</td>
<td>42</td>
<td>3 of 12: 1 week 7 of 12: 2 weeks 1 of 12: 20 weeks 1 of 12: 27 weeks 4.5 days (Range: 3–8 days)</td>
<td>60</td>
</tr>
<tr>
<td>Yongfei F; Chaoyu L et al. 2021</td>
<td>4</td>
<td>Retrospective case series</td>
<td>Isolated Lisfranc ligament</td>
<td>8: 3</td>
<td>35.4</td>
<td>11/11 (100%)</td>
<td>20.5</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td><strong>Total Average</strong></td>
<td></td>
<td></td>
<td></td>
<td>186</td>
<td>36.0 ± 7.1</td>
<td>63/74 (85.1%)</td>
<td>34.0 ± 10.2</td>
<td>55.6</td>
<td></td>
</tr>
</tbody>
</table>

**a** NR: Not Reported.  
**b** To be included in this study, these patients had a minimum 6 months of nonsurgical treatment for acute isolated Lisfranc injury.
with paraesthesia on the dorsum of the foot by 6 weeks postoperative that resolved and one case of irritation to the medial button at 3 months postoperative without subsequent reoperation [24]. Saxena et al. [26] reported one case out of six patients with postoperative degenerative joint disease. However, none of these complications required revision surgery as reported at the last follow-up.

**Coleman methodology scores**

Table 1 shows the modified Coleman methodology score we used in our review [17,18]. The modified Coleman scores range from 46 to 64 out of 100 total points within all studies (Table 2) [11,13,19–26]. The mean Coleman score was 55.7 out of 100. Gee et al. [25] was determined to be the lowest at 46 with Cottom et al. [13] as the highest at 64. Study size was generally small and did not receive points except in Cottom et al. [13] and Cho et al. [11]. None of the studies were RCTs or prospective cohort studies so they did not receive points for type of study.

**Discussion**

Upon review of the ten studies, suture button fixation shows (1) high levels of patient reported outcomes, (2) 100% rate of return to sport/activity, and (3) stable fixation in isolated Lisfranc injuries without recurrent diastasis during the postoperative follow-up period except for two cases throughout all patients in the studies. Suture button fixation technique for Lisfranc injuries provides a more physiologic reduction across the Lisfranc joint allowing some motion within the midfoot and with paraesthesia on the dorsum of the foot by 6 weeks postoperative that resolved and one case of irritation to the medial button at 3 months postoperative without subsequent reoperation [24]. Saxena et al. [26] reported one case out of six patients with postoperative degenerative joint disease. However, none of these complications required revision surgery as reported at the last follow-up.

**Table 4**

Patient-reported outcomes following surgical treatment of Lisfranc injury with suture button construct.

<table>
<thead>
<tr>
<th>Authors &amp; Publication Year</th>
<th># of patients</th>
<th>Preop AOFAS score</th>
<th>Postop AOFAS scores</th>
<th>Preop VAS</th>
<th>Postop VAS</th>
<th>Preop diastasis (mm)</th>
<th>Postop Diastasis- weightbearing (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton T; Boe C et al. 2015</td>
<td>7</td>
<td>65</td>
<td>97</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>&lt;1.0 at immediate postop</td>
</tr>
<tr>
<td>Cho J; Kim J et al. 2021</td>
<td>31</td>
<td>45.1</td>
<td>83.5</td>
<td>7.9</td>
<td>2.5</td>
<td>4.6</td>
<td>2.5</td>
</tr>
<tr>
<td>Chun H; Kim J et al. 2021</td>
<td>12</td>
<td>66.17</td>
<td>93.5</td>
<td>NR</td>
<td>NR</td>
<td>2.91</td>
<td>0.14</td>
</tr>
<tr>
<td>Cottom JM; Graney CF et al. 2020</td>
<td>84</td>
<td>30.96</td>
<td>90.3</td>
<td>8.4</td>
<td>1.3</td>
<td>3.15</td>
<td>0.43</td>
</tr>
<tr>
<td>Crates, JM; Barber, FA 2012</td>
<td>12</td>
<td>NR</td>
<td>92</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>1.9</td>
</tr>
<tr>
<td>Gee, S; Harris, MC et al. 2019</td>
<td>6</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>1.6</td>
<td>3.8</td>
<td>NR</td>
</tr>
<tr>
<td>Jain K; Drampalos E et al. 2017</td>
<td>5</td>
<td>NR</td>
<td>94</td>
<td>NR</td>
<td>0.6</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Yongfei F; Chaoyu L et al. 2021</td>
<td>11</td>
<td>NR</td>
<td>92.4</td>
<td>7.1</td>
<td>1.5</td>
<td>8.9</td>
<td>0.8 ± 1.1</td>
</tr>
</tbody>
</table>

Table 5: Return to Sports/Activity following surgical treatment of Lisfranc injury with suture button construct.

<table>
<thead>
<tr>
<th>Authors &amp; Publication Year</th>
<th># of patients</th>
<th>Return to activity rate</th>
<th>Return to activity time (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton T; Boe C et al. 2015</td>
<td>7</td>
<td>100%</td>
<td>NR</td>
</tr>
<tr>
<td>Cho J; Kim J et al. 2021</td>
<td>31</td>
<td>NR</td>
<td>12–16</td>
</tr>
<tr>
<td>Gee, S; Harris, MC et al. 2019</td>
<td>6</td>
<td>100%</td>
<td>25.9</td>
</tr>
<tr>
<td>Jain K; Drampalos E et al. 2017</td>
<td>5</td>
<td>100%</td>
<td>16.1 (return to training)</td>
</tr>
<tr>
<td>Saxena, A; Shou L et al. 2021</td>
<td>6</td>
<td>100%</td>
<td>1.6 (return to training)</td>
</tr>
<tr>
<td>Sullivan, M.; Peckston, D et al. 2022</td>
<td>12</td>
<td>100%</td>
<td>10.8 (return to training)</td>
</tr>
<tr>
<td>Yongfei F; Chaoyu L et al. 2021</td>
<td>11</td>
<td>100%</td>
<td>12 weeks</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Postoperative complications.

<table>
<thead>
<tr>
<th>Authors &amp; Publication Year</th>
<th># of patients</th>
<th>Post-operative complication rate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlton T; Boe C et al. 2015</td>
<td>7</td>
<td>0/7 (0%)</td>
<td>Implant subsidence of the round button over the medial cuneiform with bony erosion (2)</td>
</tr>
<tr>
<td>Cho J; Kim J et al. 2021</td>
<td>31</td>
<td>2/31 (6.5%)</td>
<td></td>
</tr>
<tr>
<td>Gee, S; Harris, MC et al. 2019</td>
<td>6</td>
<td>0/6 (0%)</td>
<td></td>
</tr>
<tr>
<td>Jain K; Drampalos E et al. 2017</td>
<td>5</td>
<td>1/5 (20%)</td>
<td>Transient deep peroneal nerve sensation (1)</td>
</tr>
<tr>
<td>Saxena, A; Shou L et al. 2021</td>
<td>6</td>
<td>1/6 (16.7%)</td>
<td>Postoperative degenerative joint disease (1)</td>
</tr>
<tr>
<td>Sullivan, M.; Peckston, D et al. 2022</td>
<td>12</td>
<td>2/12 (16.7%)</td>
<td>Transient foot paraesthesia by 6-week postop follow-up (1)</td>
</tr>
<tr>
<td>Yongfei F; Chaoyu L et al. 2021</td>
<td>11</td>
<td>0/11 (0%)</td>
<td>Irritation to the medial button at 3-month postop follow-up (1)</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>6/78 (7.7%)</td>
<td></td>
</tr>
</tbody>
</table>
reduces the need for reoperation including removal of hardware. No revision cases were noted in our systematic review.

Ligamentous injuries can be subtle and missed approximately 20% on initial presentation [18,27–29], resulting in chronic midfoot pain, progressive deformity, and prolonged disability [30–32]. Regardless of the injury pattern, achieving a good reduction at the Lisfranc joint is essential to good outcomes [33]. Primary stable arthrodesis is a mainstay of purely ligamentous Lisfranc injuries [6,34] with trans-articular screw or dorsal bridge plate fixation as alternative management with good outcomes [28, 35–37]. These constructs provide rigid fixation and reduce motion in the medial column while preserving range of motion in the lateral column. However, it is unclear if routine hardware removal is needed [38]. Furthermore, rigid fixation prevents motion of the medial column [39] which leads to pain or screw breakage during strenuous activity. Metal irritation and wound healing have also been reported in rigid fixation constructs of the Lisfranc joint [6,7]. Nevertheless, other evidence suggests achieving anatomic reduction is more important than the fixation method for functional outcomes [36]. Suture buttons may provide comparable outcomes to these techniques including early return to play [19,21,22,24–26], no need for hardware removal or revision [11,22,24], improved patient reported outcomes [11,13,19–22], and small amounts of diastasis [11,19,21].

For Lisfranc injuries in athletes, athletes returning to sport may put fixation under higher stress, leading to higher chances of screw breakage. Screw breakage, which can result in reoperation, further delays recovery in athletes. This delay in return to sport or duty is crucial to individual and team success as well as lost wages. Across our review, there is significant evidence that suture button fixation allows for high levels of return to sport. In elite athletes and military members, return to sport was 100% across 67 patients [11,21,22,24–26] with no revisions. Within the military population, 100% of patients undergoing suture button fixation returned to full duty after sustaining isolated ligamentous while only 50% were found to return after screw fixation. This may potentially be due to wound complications of hardware and the high levels of removal in that patient population. In a less athletic population, 23 patients were able to return to sports/activity 100% of the time [19,20]. High rates of return to sport among high- and low-level athletes support suture button as a reliable construct for Lisfranc injury, with little variability between studies. Comparatively, a recent systematic review found 94% of 270 patients returned to sport postoperatively following ORIF and 94% of 65 patients returned following arthrodesis [40]. While our series of Lisfranc patients is slightly less robust than the group of ORIF patients, this high return to sport shows comparable outcomes observed with alternative fixation methods.

Suture button fixation is advantageous in athletes as it may allow for early weight-bearing and a small incision, which could aid in return to play or activity. Several authors allowed weight-bearing at 6 weeks [22, 41] with the suture button, earlier than the 8 weeks of non-weight-bearing standard for screw fixation. In a cohort of 12 elite athletes, Sullivan et al. [24] found all athletes were able to weight-bear by 4 weeks with full competition in 12–16 weeks. This was speculated to be due to the larger suture button device of 3.7 mm suture button vs the mini 2.7 mm interosseous suture button used in other series. Among a cohort of 5 English premier league soccer and rugby players, mean return to sport was 16.1 weeks [22]. Within a military population, return to duty was only 181 days in the suture button group compared to 358 days in the screw fixation group [25], potentially due to problematic hardware in the screw group that required removal. Comparatively, studies utilizing suture fixation yielded return to sport at an average of 24.1 weeks [42], 29.4 weeks [43], 8 months [44], and 6.9 months [45]. Therefore, suture button fixation shows comparable outcomes for Lisfranc treatment in athletes to allow early return to sport at a similar overall rate compared to return to sport reported in studies utilizing screw fixation.

Patient reported outcomes, including VAS and AOFAS scores, greatly improved postoperatively after suture button fixation. Postoperatively, AOFAS score ranged from 83.5 to 97 [11,13,19–22] while VAS ranged from 0.6 to 2.5 [11,13,20,22,25] in this review. These findings are comparable to the reported VAS scores of 0.13 after arthrodesis and 1.0 after ORIF [46]. Within this review, Cho et al. [11] detected superior patient reported outcomes at 6 months follow-up compared to the screw group which they hypothesized may be due to increased metatarsal foot pressure due to a more rigid construct. In a smaller study, Gee et al. [25] found no difference in VAS at last follow-up between screw vs suture button fixation, although this study has limited external validity as it was limited to 12 young, healthy patients. Therefore, suture button fixation may have equivalent patient reported outcomes to screw fixation in the limited studies comparing these two techniques. However, this conclusion is limited by the small sample sizes and studies comparing patient reported outcomes in patients with suture button vs screw fixation. Low rates of diastasis were demonstrated across studies, ranging from 0.14 to 2.5 mm postoperatively [11,19–21], potentially due to favourable biomechanical properties compared to screw fixation. These findings support good reduction across the Lisfranc joint that is consistent between studies. Suture button fixation is suspected to reduce injury to soft tissue and provides a more physiological means of fixation similarly to its utilization for syndesmotic stabilization [47]. Studies in animal models suggest that rigid fixation of ligaments may disrupt healing [48, 49]. With decreased implant fatigue or breakage, removal is not indicated of the suture button. Micromotion across the joint may also allow for early weight bearing. In a cadaveric study, Pelt et al. [50] found suture button restrained motion to pre-injury levels. Furthermore, Panchehavai et al. found that in a cadaver study, there was no difference in displacement from repair of isolated Lisfranc injury between screw and suture button fixation [51]. As anatomic fixation across the Lisfranc joint is essential for good outcomes [36], a dual suture button construct is thought to be more anatomic and stronger. Crates et al. [52] found no late diastasis with two suture buttons and equivalent AOFAS scores compared to a dual screw construct. Clinically, Crates et al. [23] found high patient reported outcomes at 18 months, in 12 patients treated with a dual tightrope construct. Thus, for patients in whom anatomic reduction is more challenging, a construct with two suture buttons may be indicated.

Potential complications may be caused by late diastasis and the learning curve of the procedure. To further reduce complications, Sullivan et al. [24] used a knotless suture button to avoid the risk of knot irritation or suture abscess. Furthermore, suture button fixation that utilizes a 2 mm drill instead of a 3.5 mm may minimize damage to cartilage and surrounding structures. Placing the cylindrical suture button longitudinally may limit soft tissue irritation and stress concentration on the second metatarsal [11]. Furthermore, Baravarian [53] recommends tying on the side of the medial cuneiform to minimize irritation to the 2nd metatarsal base and the associated neurovascular bundle. Cho et al. [11] did report subsidence in two older patients, leading to recurrent diastasis after tensioning the subsided suture button at the medial cuneiform. This complication was suspected to be due to poor bone quality in which a more rigid construct may be more successful. Ultimately, the combined rate of complications of 6.7% is much lower than previously reported rates of 23.1% following ORIF and 30.2% following arthrodesis [54]. Hardware removal has been reported as high as 43.6% for ORIF and 18.4% after arthrodesis compared to 0% after suture button fixation [54]. While more studies are required to directly compare suture button fixation to the current standard fixation techniques, there is evidence for lower rates of complications and revision rates with suture button fixation for Lisfranc injuries. Lower rates of reoperation and complications would likely significantly decrease cost for patients while improving patient satisfaction.

Several case reports and technical papers have also reported successful use of suture button fixation for Lisfranc injuries. Brit et al. [41] used suture button fixation in five healthy young patients suffering Lisfranc injury with all patients except one showing very high satisfaction and AOFAS scores at one year. These patients all were allowed full weight-bearing at 6 weeks and returned to sport by 3 months. In a series of
three young patients undergoing suture button fixation for Lisfranc injury, all patients reported no pain, satisfactory bone and joint healing, and return to activity at 10 months [12]. For patients requiring more fixations, Lundeen et al. added a washer to augment suture button fixation for revision cases [55]. Delman et al. proposed utilizing the internal brace to better replicate native anatomy and joint mechanics while minimizing reoperation [56]. Nery and Baufeld found good reduction of the Lisfranc joint at 8 months with a suture tape and bioabsorbable screw construct [57]. Flexible fixation with a construct of fiber wire tied around screws with a washer in the distal 1st metatarsal and medial cuneiform has also been described with successful outcomes [58]. These case reports and technical papers further support the efficacy of suture button fixation and other flexible fixation constructs for isolated Lisfranc injury.

Mean Coleman scores were 55.7 out of 100 ranging from ranges from 4625 to 64 [13,25]. Scores were generally limited as there were no RCTs or prospective cohort studies included in this review, without yielding points for type of study. Studies also widely varied on post-intervention rehabilitation and outcomes criteria. Furthermore, most studies have follow-up with 12–24 months, decreasing scores across studies. Only Cottom et al. [13] and Sullivan et al. [24] received points for study size as other studies were deemed small. Cottom et al. [13] scored the highest as it had the longest follow-up and study size while Gee et al. [25] had a small sample size, shorter follow-up and did not describe their methodology in as much depth. While these Coleman scores may appear low, Lisfranc injuries are relatively rare and suture button fixation is an emerging technique. Thus, one would expect small sample size, with limited follow up; thus, further studies such as large sample size RCT studies are recommended. Within the context of this rare injury and new technique, these scores may be interpreted as solid evidence to support suture button fixation.

Several limitations of this current study have to be mentioned. Systematic reviews are inherently limited by the relevant data reported in the literature. To date, there has been no level one or level two studies regarding Lisfranc injuries treated with suture buttons. Thus, the current study carries the same biases as those of non-randomized and retrospective analyses. The sample size of the studies included in this review was relatively small. The results should thus be interpreted with caution. There were only two comparative level 3 case control studies in this review, which was relatively small. The results should thus be interpreted with caution.

In our systematic review, suture button fixation shows high levels of patient reported outcomes, return to sport, and stable fixation in isolated Lisfranc injuries. This surgical technique provides a physiologic reduction across the Lisfranc joint and reduces the need for reoperation including removal of hardware. However, further evidence such as large sample size high-quality RCT studies is needed to draw a definitive conclusion regarding the best treatment for Lisfranc injuries.

Conclusions

In our systematic review, suture button fixation shows high levels of patient reported outcomes, return to sport, and stable fixation in isolated Lisfranc injuries. This surgical technique provides a physiologic reduction across the Lisfranc joint and reduces the need for reoperation including removal of hardware. However, further evidence such as large sample size high-quality RCT studies is needed to draw a definitive conclusion regarding the best treatment for Lisfranc injuries.

Conflict of interests

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References


