Isolated Medial Cuneiform Fractures

A Systematic Search and Qualitative Analysis of Case Studies

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Background: Isolated medial cuneiform fracture is a rare but diagnostically challenging condition. Diagnostic delay in these cases may lead to delays in ideal treatment approaches and prolonged symptoms. An understanding of clinical presentation is needed to expedite diagnosis, facilitate decision making, and guide treatment approach.

Methods: Case studies/series were searched in four databases until September 2019. Included studies had participants with a history of traumatic closed medial cuneiform fracture. Studies were excluded if the medial cuneiform fractures were open fractures, associated with multitrauma, or associated with dislocation/Lisfranc injury. Three blinded reviewers assessed the methodological quality of the studies, and a qualitative synthesis was performed.

Results: Ten studies comprising 15 patients were identified. Mean ± SD patient age was 38.0 ± 12.8 years, with 86.7% of reported participants being men. The overall methodological quality was moderate to high, and reporting of the patient selection criteria was poor overall. The most commonly reported clinical symptoms were localized tenderness (60.0%) and edema (53.3%). Direct blow was the most common inciting trauma (46.2%), followed by axial load (30.8%) and avulsion injuries (23.1%). Baseline radiographs were occult in 72.7% of patients; magnetic resonance imaging and computed tomography were the most common diagnostic modalities. Mean ± SD diagnostic delay was 64.7 ± 89.6 days. Conservative management was pursued in 54.5% of patients, with reported resolution of symptoms in 3 to 6 months. Surgical intervention occurred in 45.5% of patients and resulted in functional restoration in 3 to 6 months in all but one patient.

Conclusions: Initial radiographs for isolated medial cuneiform fractures are frequently occult. Due to expedience and relatively low cost, radiographs are still a viable first-line imaging modality. If clinical concern remains, magnetic resonance imaging may be pursued to minimize diagnostic delay. Conservative management is a viable treatment method, with expected return to full function in 3 to 6 months. (J Am Podiatr Med Assoc 111(4): 1-9, 2021)

Traumatic foot injuries are a common presentation in emergency departments.¹⁻³ These injuries can cost up to $21,801 to manage and are compounded by loss of productivity and salary by the employer and employee, respectively.¹⁻⁵ The three cuneiform bones of the foot (medial, intermediate, and lateral) and their articulations are relatively small and well protected from injury, primarily due to the extensive ligamentous structures around these articulations.⁶ Although there is motion between the cuneiform bones, it is slight and limited to gliding motions.⁷ Due to the inherent stability of these joints, isolated fracture in the absence of ligamentous disruption or dislocation is rare, accounting for approximately 2% of all tarsal fractures.⁸
Evidence-based guidelines such as the Ottawa Ankle Rules and the American College of Radiology Appropriateness Criteria are effective in aiding clinicians to rule out fracture in patients with foot trauma.\textsuperscript{9-12} Although these guidelines currently constitute best practice, they do not achieve 100% sensitivity to rule out fracture and may lead to a lack of baseline imaging in isolated cuneiform fractures.\textsuperscript{13-15} When radiographs are ordered, midfoot fractures are often occult, which can lead to delayed diagnosis and prolonged patient disability.\textsuperscript{16-21} Olson et al\textsuperscript{22} previously reported that the diagnosis of nondisplaced medial cuneiform fractures may be delayed or even missed completely because these fractures are subtle or occult on plain film radiographs, especially when taken in a nonweightbearing position. Furthermore, in this region of the foot, radiographs can be particularly difficult to interpret because of multiple overlapping shadows of the cuneiform bones.\textsuperscript{7} Therefore, advanced imaging, such as skeletal scintigraphy, computed tomography (CT), or magnetic resonance imaging (MRI), may be necessary during patient evaluation to make the correct diagnosis in a timely manner.\textsuperscript{7,22}

Although individual case studies detail the diagnosis and management of isolated medial cuneiform injuries, we were unable to locate any research publications that comprehensively describe the evaluation and management of isolated fracture of the medial cuneiform. No known composite patient presentation has been established to supplement clinical decision making where imaging guidelines may fail. Although the American College of Radiology Appropriateness Criteria support advanced imaging in patients with suspected occult foot fractures, no systematic review has reported which modality may be ideal for isolated medial cuneiform fractures. Although individual case reports have documented success with both conservative and surgical interventions in this patient population, no comprehensive study exists to direct which treatment approach may be best pursued.\textsuperscript{23,24}

The main purpose of this study was to conduct a systematic search, critical appraisal, and qualitative synthesis of the evidence on the clinical presentation of patients with medial cuneiform fractures. A secondary aim of this study was to identify a potential diagnostic imaging pathway for these injuries. Finally, the study aimed to establish an understanding of conservative management and surgical intervention treatment outcomes.

\section*{Materials and Methods}

\section*{Search Strategy}

A comprehensive literature search was completed using the following databases: CINAHL, SPORTdiscus, PubMed (Medline), and Scopus. Limits applied included English language and studies on human subjects, and it was conducted from inception until September 2019. Search terms used were \textit{(fracture) AND (medial cuneiform OR first cuneiform OR 1st cuneiform)}.

\section*{Inclusion and Exclusion Criteria}

Studies were considered eligible for inclusion if they were case vignettes, case reports, or case series with participants who had a history of traumatic closed medial cuneiform fracture. Studies were not considered eligible if any of the following were found: 1) studies in which the medial cuneiform fracture was considered to be a stress (fatigue or insufficiency) fracture; 2) studies in which the medial cuneiform fracture was an open fracture, was associated with concurrent dislocation or Lisfranc injury, or was associated with multitrauma (such as multiple fractures); 3) studies that did not report clinical presentation or clinical course of care; and 4) cadaveric studies.

\section*{Study Selection}

After articles were identified using the previously defined search strategy, duplicates were removed. Two independent reviewers, L.M.M. and T.N.P., screened titles and abstracts to determine eligibility for full-text consideration. Reviewers were blinded to one another’s results during the screening process. After screening titles and abstracts, full-text articles were reviewed for final inclusion consideration. When a consensus could not be reached between reviewers, a third reviewer (A.S.G.) was consulted.

\section*{Data Extraction}

Data were extracted independently by L.M.M. and A.S.G. using a standardized spreadsheet to record author(s), year of publication, and study population (sex, age); mechanism of injury; trauma type; initial/managing provider; ability to walk immediately after injury; baseline and secondary imaging types; presence of antalgic gait pattern; presence of ecchymosis, edema, or erythema; palpatory tender-
ness; diagnostic delay period; treatment approach; and outcome. Consensus was reached by discussion.

Assessment of Methodological Quality

Both L.M.M. and T.N.P. completed a bias assessment of the final ten articles using the Murad criteria.25 Two of the eight bias assessment criteria were excluded because they pertained specifically to pharmaceutical studies: was there a challenge/rechallenge phenomenon and was there a dose-response effect. Therefore, six of the eight criteria were used for the bias assessment. Both L.M.M. and T.N.P. were blinded to one another’s quality scores during the scoring process, and A.S.G. resolved any discrepancies between the two reviewers on the quality score of each article.

Synthesis of Results

Qualitative synthesis of the articles was performed with Microsoft Excel 2016 (Microsoft Corp, Redmond, Washington). Descriptive statistics, including ranges, counts, and averages, were calculated with either Microsoft Excel 2016 or the Microsoft calculator application 2018 version 10.1804.11545.0 (Microsoft Corp).

Results

Study Selection

In total, 194 studies were identified from the database searches (Fig. 1). After removal of duplicates and screening of titles and abstracts, 15 studies remained for full-text analysis. Of those 15 studies, five were eliminated for the following reasons: no defined medial cuneiform fracture,26 atraumatic medial cuneiform fracture,27,28 no clinical course reported,29 and multitrauma.30 Ten studies were, therefore, included in the qualitative analysis. Fifteen patient cases from these ten peer-reviewed publications were found.22-24,31-37

Study Characteristics

Table 1 reports the main characteristics of the included studies and patients. Patient ages ranged from 21 to 62 years (mean ± SD, 38.0 ± 12.8 years), with 13 men (86.7%) and two women (13.3%). Thirteen patients reported a type of trauma, of which a direct blow was the most common etiology (46.2%), followed by axial compression (30.8%), with avulsion fractures having the lowest etiologic frequency (23.1%). Ten patients detailed first-line providers, the most common of which was the emergency department (60.0%), although a portion of initial presentations occurred at the primary care provider (20.0%) or orthopedics (20.0%). Seven of 11 patients were finally managed by orthopedics (63.6%), with podiatry treating three patients (27.3%) and physical therapy treating one (9.1%).

Localized palpatory tenderness was the most commonly reported clinical finding, occurring in nine patients (60.0%). An antalgic gait pattern was present in four patients (26.7%). Localized edema was present in eight patients (53.3%), ecchymosis in three (20.0%), and erythema in one (6.7%). Of note, many case reports failed to mention either the presence or absence of these findings, which may suggest that these percentages are lower than what were clinically present.

Baseline radiographs were reported in 11 of the 15 patients, and of these, eight were occult (72.7%). Of the eight patients with occult imaging, three with MRI,22,23,33 four with CT,32,34-36 one with bone scan, and one of three with repeated radiographs (33.3%)22,36 were diagnostic. In the patient with the bone scan, CT was also ordered due to the inherent low specificity of bone scan.22

Eleven cases reported treatment approaches with clinical outcomes. Six patients were treated conservatively (54.5%) and five were treated surgically (45.5%). Those treated conservatively were commonly prescribed 6 to 8 weeks of nonweightbearing,
<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Sex</th>
<th>Age (Years)</th>
<th>Mechanism</th>
<th>Trauma Type</th>
<th>Baseline Imaging</th>
<th>Secondary Imaging</th>
<th>Diagnostic Delay</th>
<th>Treatment Approach</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choi et al31  (2019)</td>
<td>M</td>
<td>49</td>
<td>Fall</td>
<td>Avulsion</td>
<td>Radiographs</td>
<td>CT</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>49</td>
<td>Fall</td>
<td>Avulsion</td>
<td>Radiographs</td>
<td>CT</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>58</td>
<td>Pedestrian versus vehicle</td>
<td>Avulsion</td>
<td>Radiographs</td>
<td>CT</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Mabry et al23 (2019)</td>
<td>F</td>
<td>25</td>
<td>Kicked wall</td>
<td>Axial compression</td>
<td>Radiographs, occult</td>
<td>CT, MRI, diagnostic</td>
<td>3 1/2 wk</td>
<td>NWB × 3 d, CAM boot × 2 wk, footwear restrictions × 6 wk</td>
<td>Full function with mild pain at 3 mo s/p</td>
</tr>
<tr>
<td>Babu et al24  (2017)</td>
<td>M</td>
<td>42</td>
<td>Fall of 15 ft</td>
<td>Axial compression</td>
<td>Radiographs, diagnostic</td>
<td>CT</td>
<td>0 d</td>
<td>Primary arthrodesis, temporary NWB</td>
<td>Full function with mild pain at 4 mo s/p</td>
</tr>
<tr>
<td>Alemdar et al32 (2013)</td>
<td>M</td>
<td>62</td>
<td>Trauma</td>
<td>Unclear</td>
<td>Radiographs, occult</td>
<td>CT, diagnostic</td>
<td>9 mo</td>
<td>Primary arthrodesis</td>
<td>NR</td>
</tr>
<tr>
<td>Eraslan et al33 (2013)</td>
<td>M</td>
<td>42</td>
<td>Motorcycle accident</td>
<td>Direct blow</td>
<td>Radiographs, occult</td>
<td>MRI, diagnostic</td>
<td>10 d</td>
<td>Short-leg cast × 20 d, NWB × 6 wk</td>
<td>Full function at 6 mo s/p</td>
</tr>
<tr>
<td>Guler et al34 (2011)</td>
<td>M</td>
<td>32</td>
<td>Motorcycle accident</td>
<td>Direct blow</td>
<td>Radiographs, diagnostic</td>
<td>CT</td>
<td>0 d</td>
<td>ORIF, cast × 10 d, NWB × 6 wk</td>
<td>Full function and pain free at 6 mo s/p</td>
</tr>
<tr>
<td>Taylor and Heldenreich35 (2008)</td>
<td>M</td>
<td>26</td>
<td>Combatives training</td>
<td>Direct blow</td>
<td>Radiographs, occult</td>
<td>CT, diagnostic</td>
<td>4 mo</td>
<td>Cast and NWB × 6 wk</td>
<td>Full function</td>
</tr>
<tr>
<td>Olson et al22 (2000)</td>
<td>M</td>
<td>39</td>
<td>Golf cart accident</td>
<td>Direct blow</td>
<td>Radiographs, occult</td>
<td>Repeated radiographs, diagnostic</td>
<td>NR</td>
<td>Cast × 6 wk, NWB × 8 wk</td>
<td>Full function and pain free at 3 1/2 mo s/p</td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>27</td>
<td>Eversion injury</td>
<td>Unclear</td>
<td>Radiographs, MRI, occult</td>
<td>Repeated radiographs, occult/Repeated MRI, diagnostic</td>
<td>6 wk</td>
<td>Cast immobilization × 6 wk, NWB × 8 wk</td>
<td>Full function with mild pain at 3 mo s/p, pain free at 1 y s/p</td>
</tr>
<tr>
<td>Bryant and Baird36 (1993)</td>
<td>F</td>
<td>47</td>
<td>Fall, dorsiflexion injury</td>
<td>Axial compression</td>
<td>Radiographs, MRI, occult</td>
<td>Repeated radiographs, occult/bone scan, diagnostic/CT</td>
<td>6 mo</td>
<td>ORIF</td>
<td>Mild pain and mild functional deficits at 6 mo s/p</td>
</tr>
<tr>
<td>Patterson et al37 (1993)</td>
<td>M</td>
<td>21</td>
<td>Motorcycle accident</td>
<td>Direct blow</td>
<td>Radiographs, diagnostic</td>
<td>None</td>
<td>0 d</td>
<td>ORIF, cast/NWB × 6 wk</td>
<td>Full function and pain free at 3 mo s/p</td>
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Abbreviations: CAM, controlled ankle motion; CT, computed tomography; MRI, magnetic resonance imaging; NR, not reported; NWB, nonweightbearing; ORIF, open reduction and internal fixation; s/p, status post.
with return to full function in 3 to 6 months. Note, however, that in one case the patient advanced herself to full weightbearing 3 days after the injury and still achieved full function with conservative care at the 3-month mark. Although most surgical interventions reported a return to full function in 3 to 6 months, one patient reported ongoing functional deficits at the 6-month mark.

Diagnostic delay was reported in ten patients and ranged from 0 days to 9 months. The mean ± SD diagnostic delay was 64.7 ± 89.6 days and was primarily composed of provider delay. One case did, however, report a 2-month patient delay before first seeking treatment.

Methodological Quality Assessment of Studies

Bias for all ten studies was evaluated on a 6-point scale where higher percentages suggest lower levels of bias and lower percentages suggest higher levels of bias (Table 2). Bias scores ranged from 2 to 5 points on the 6-point scale (33.3%-100.0%). The average bias score across all studies was 4.5 points (75.0%), suggesting a low-to-moderate level of bias. A common weakness of the studies was a failure to report the patient selection method. The following metrics were reasonably well represented by the included studies: adequate exposure; adequate outcome; alternative causes of symptoms; sufficient follow-up; and reproducibility.

Discussion

Isolated medial cuneiform fractures are rare and diagnostically challenging; they are typically occult on baseline radiographs. Noncontributory imaging may lead to diagnostic delay and may unnecessarily prolong patient suffering. Because this condition is exceedingly rare, to our knowledge, no studies have been published with greater methodological rigor than the case studies/series presented in these findings. This is the first article to present a systematic search and comprehensive synthesis of presentation, diagnosis, and treatment of isolated medial cuneiform fractures.

Only one patient reported an inability to walk at the time of injury, indicating a positive finding on the Ottawa Ankle Rules. This would suggest a risk of a patient failing to receive baseline imaging if evidence-based guidelines for imaging are followed. Because the Ottawa Ankle Rules do not always achieve 100% sensitivity, it may be of value to add medial cuneiform tenderness to the rules to minimize the chance of a missed fracture. Other authors have similarly suggested updates to the Ottawa Ankle Rules to improve overall yield. Although this addition may improve the sensitivity of the rules, it may also have a negative effect on specificity, which warrants further investigation.

Localized palpatory tenderness, edema, and antalgic gait pattern were present in all of the reported patients. Although this may aid in diagnosis, these symptoms would be similarly experienced in

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Bias Assessment Criteriaa</th>
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<tr>
<td>Choi et al (2019)</td>
<td>X X X X X</td>
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<tr>
<td>Mabry et al (2019)</td>
<td>X X X X X</td>
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<tr>
<td>Babu et al (2017)</td>
<td>X X X X X</td>
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<tr>
<td>Alemdar et al (2013)</td>
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<td>Eraslan et al (2013)</td>
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<td>Guler et al (2011)</td>
<td>X X X X</td>
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<tr>
<td>Taylor and Heidenreich (2008)</td>
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<td>Olson et al (2000)</td>
<td>X X X X X</td>
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<td>Bryant and Baird (1993)</td>
<td>X X X X</td>
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<tr>
<td>Patterson et al (1993)</td>
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aBias assessment criteria were as follows: 1: Does the patient(s) represent(s) the whole experience of the investigator (center) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported? 2: Was the exposure adequately ascertained? 3: Was the outcome adequately ascertained? 4: Were other alternative causes that may explain the observation ruled out? 7: Was follow-up long enough for outcomes to occur? 8: Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners to make inferences related to their own practice? Two of the eight bias assessment criteria were excluded because they pertained specifically to pharmaceutical studies: 5: Was there a challenge/rechallenge phenomenon? 6: Was there a dose-response effect?
patients with a diagnosis of a Lisfranc injury. \cite{45} Mechanisms for isolated medial cuneiform fractures are also consistent with those for Lisfranc injuries. \cite{46} Similar to medial cuneiform fractures, Lisfranc injuries are frequently misdiagnosed \cite{47-49} and may present as occult on baseline radiographs. \cite{45,50} Distinguishing between these diagnoses is of utmost importance because isolated medial cuneiform fractures may be treated conservatively \cite{23,33,35} whereas Lisfranc injuries may result in poor outcomes unless treated surgically. \cite{51-53} Note that these articles were largely silent on the presence or absence of clinical findings typically associated with Lisfranc injuries, such as loss of arch height, the plantar ecchymosis sign, or toe gapping. \cite{54-56}

Although baseline radiographs were commonly occult, they were diagnostic in three of 11 patients. This finding is consistent with previous evidence suggesting that midfoot fractures are typically occult on baseline radiographs. \cite{57,58} However, given the low radiation exposure, expedience, and cost-effectiveness of plain film radiographs, these may still offer value as a primary imaging modality. \cite{59,60} Lisfranc injury would be a typical differential diagnosis of isolated medial cuneiform fractures before imaging results. Given the ability for weight-bearing foot radiographs to aid in ligamentous disruption via expansion of joint spaces, we suggest weightbearing foot radiographs as tolerated to aid in this differential diagnosis. \cite{61-63} This recommendation is consistent with the American College of Radiology Appropriateness Criteria for traumatic midfoot injuries. \cite{9}

The present study found that neither repeated radiographs nor bone scans were definitively diagnostic in patients with isolated medial cuneiform fractures. \cite{22,36} These findings suggest that repeated radiographs or bone scans are not the optimal secondary imaging choice. Conversely, MRI or CT may potentially be of greatest diagnostic value because both modalities led to a definitive diagnosis as a secondary imaging modality. \cite{22,33,32-36} Given the ability of MRI to rule out a concomitant Lisfranc injury, it may hold superior diagnostic capability over CT. \cite{64-66} With that in mind, we propose a diagnostic flow diagram to aid in identifying isolated medial cuneiform fractures (Fig. 2).

Diagnostic delay in these patients was primarily composed of provider delay. Patient delay was minimized because many patients reported immediately to the emergency department after the injury. This finding is consistent with delays reported in other traumatic isolated midfoot frac-

Figure 2. Isolated medial cuneiform fracture diagnostic and treatment flow diagram. CT, computed tomography; MRI, magnetic resonance imaging.
tures.7,67 More insidious sources of foot pain tend to lead to greater duration of patient delays compared with provider delays.68-70 Given the qualitative analysis in this study, progressing to MRI in patients with traumatic foot injuries with tenderness at the medial cuneiform may minimize provider delay while expediting the requisite rehabilitative treatments.

This article is limited by the methodological rigor of its included studies, as the highest level of evidence for isolated medial cuneiform fractures in this review is case studies/series. Although studies overall had low-to-moderate bias, selection bias was common among the studies. Future studies should explore changes in the diagnostic properties of the Ottawa Ankle Rules if medial cuneiform tenderness is added to the foot protocol.

Conclusions

An isolated medial cuneiform fracture is a rare but diagnostically challenging injury that leads to average diagnostic delays of 2 months. Patients commonly present with localized tenderness and edema. Initial radiographs are frequently occult; however, due to expediency and relatively low cost, radiography is still a viable first-line imaging modality. If clinical concern remains, findings from this review suggest that MRI may be pursued to minimize diagnostic delay. Conservative management is a viable treatment method, with expected return to full function in 3 to 6 months.

Financial Disclosure: None reported.
Conflict of Interest: None reported.

References

59. LEAVER T, JOHNSON B, LAMPARD J, ET AL: The risks following the exposure to radiation associated with the surgical


