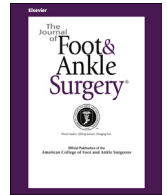




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Case Reports and Series

Classification and Outcome of Fracture-Dislocation of the Cuneiform Bones

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ABSTRACT

Fractures and dislocations of the cuneiform bones are rare injuries to the midtarsal foot. The injury severity is often unclear, and the prognostic factors are unknown. The purpose of the present study was to characterize our insights of the diagnostics, therapy, and fracture patterns. We questioned whether the number of involved cuneiform bones and the type of injury would affect the clinical outcome. With this information, we aimed to develop a classification system for injuries of the cuneonavicular joint. Five patients who had sustained complex fracture-dislocation of the cuneiform bones were prospectively registered, underwent surgery, and were followed up. We reviewed the published data and found 47 reports that included 55 patients to improve the informative value of our study. The injury mechanisms and therapy were evaluated, and the postoperative limitations and pain were assessed. The clinical outcome was correlated with the number of involved cuneiforms and the fracture/dislocation pattern. Direct trauma was associated with isolated fracture, and indirect injury was associated with isolated dislocations. Occasionally, these injuries were overlooked on conventional radiographs, and closed reduction frequently failed. The number of cuneiform bones involved and the type of injury were shown to affect the clinical outcome. We devised an easily applicable classification system for injuries to the cuneiform bones using this information. All cases were classified as isolated fractures (1), isolated dislocations (2), or fracture-dislocations (3) involving 1 (A), 2 (B), or 3 (C) cuneiform bones. The classification system we propose will facilitate a better understanding of the fracture patterns at the cuneonavicular joint line and is a good prognostic tool that requires validation in clinical settings.

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Injuries to the cuneonavicular joint line are considered rare mid-foot injuries. The number of published reports focusing on such trauma has nevertheless increased. Currently, 47 case reports have discussed cuneiform bone injuries. Estimates have revealed that cuneiform bone injuries account for $\geq 1.7\%$ of all tarsal fractures (1,2).

It would seem crucial to address ligamentous connections to this articulation when considering luxation or luxation fractures of the cuneonavicular joint. The medial cuneiform is fixed by strong cuneonavicular ligaments that connect to the intermediate cuneiform by a strong interosseous ligament and is attached to the first and second metatarsals by a strong plantar metatarsocuneiform ligament, considered the key to the metatarsal arch (3). The intermediate cuneiform is fixed by a thin dorsal and plantar cuneonavicular ligament and is connected by thin dorsal intercuneiform and

metatarsocuneiform ligaments; corresponding plantar ligaments are absent. The lateral cuneiform is fixed by dorsal and plantar cuneonavicular ligaments, 3 cuneocuboidal ligaments, and dorsal and plantar metatarsocuneiform ligaments (3). Thus, the intermediate cuneiform is the weakest part of the cuneiform arch (2,4).

The anatomic form of the intermediate cuneiform–prism shape with a dorsal base and the weak plantar ligamentous fixation favors dislocation in the dorsal direction (5–7). In contrast, the wedge shape combined with the medial cuneiform's plantar base supports a medial–plantar dislocation (8,9). Finally, the wedge shape and dorsal base of the lateral cuneiform predisposes to dorsal dislocation (10).

Once dislocation has occurred, adequate therapy has included open and closed reduction and screws or Kirschner wires for fixation. The clinical outcomes after surgical treatment have varied widely, with some patients experiencing severe pain and limitations in daily living resulting from post-traumatic osteoarthritis (11–13). Other patients will experience mild or no pain and no restrictions to their daily routine (8,14–18). Currently, no evidence is available of any parameters that can be used to predict the clinical outcome of treatment of cuneonavicular injuries.

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We hypothesized that the number of involved cuneiform bones and the type of fracture (dislocation or fracture-dislocation) would affect the clinical outcome. Using this information, we aimed to develop a classification system for injuries of the cuneonavicular joint with prognostic value. In the present cohort study, we followed up patients who had sustained a complex fracture-dislocation of the cuneonavicular joint and assessed the short-term clinical outcomes in terms of the early development of arthritis, pain, and limitations of daily living. Furthermore, we aimed to characterize new insights in the diagnostics, therapy, and fracture pattern of such injuries.

Patients and Methods

Accrual and Follow-Up of Our Patients

From January 2009 to December 2011, 5 consecutive patients with an injury to the cuneiform bones were admitted to our hospital. All had presented with isolated injuries to the cuneonavicular joint line, which were seen on plain radiographs and confirmed by computed tomography (CT) scan. Primary surgery was performed within the first 48 hours after injury and included open reduction and internal fixation with Kirschner wires (K-wires), screws, and locking plates. An additional external fixator for soft tissue protection was mounted in 2 patients. Once their wounds had definitively healed, the patients were discharged from the hospital, and lymphatic drainage and physiotherapy were applied for 4 weeks. Weightbearing in a walker boot (Vacoped™; OPEd, Valley/Oberlindern, Germany) was limited to 15 kg for 6 weeks and then weightbearing was increased. The external fixator and K-wires were removed after 8 weeks, and the screws and plates were left in situ. The patients were required to wear the walker boot for 8 weeks. After 6 months for 3 patients and 36 months for 2 patients, the clinical and functional outcomes were assessed using the German Foot Function Index (19) and American Orthopaedic Foot and Ankle Society midfoot scale with special regard to pain (none, moderate, severe) and activities of daily living (unlimited, limited, or severely limited) (20,21).

Review and Online Search

We conducted an OVID-based systematic data search of the MEDLINE, EMBASE, and Life Science databases applying the key words “cuneiform” [and/or] “fracture” [and/or] dislocation. The search period ranged from January 1967 until December 2014. We identified 47 case reports with 55 patients.

Assessment of Relevant Clinical Parameters From the Case Reports

The variety and combination of forces that can be brought to bear on the forefoot are considerable and is the reason for the many patterns and types of fractures of the cuneonavicular joint. We distinguished indirect and direct mechanisms among all 55 patients. Indirect mechanisms included a fall from a height, motor vehicle accident, hyperplantarflexion or hypersupination, or apparently trivial trauma, and direct included a tremendous force involving direct impact. We also recorded the point of diagnosis (primary medical consultation or delayed [>7 days]) and whether the diagnosis had been made from plain radiographs, CT scan, or intraoperative evaluation by open reduction. The treatment type was also analyzed with respect to cases involving failed closed fracture reduction or fracture-dislocation.

Clinical Outcome Grade in the Case Reports

The 47 case reports (55 patients) were analyzed concerning the clinical follow-up data and any information about pain and

limitations of daily living at the end of the clinical follow-up period. Using the American Orthopaedic Foot and Ankle Society midfoot scale (20,21) and generally simplified, we noted whether pain was none/mild (score of 1), moderate (score 2), or severe (score 3), and whether the daily activities were unlimited (score 1), limited (score 2), or severely limited (score 3). The pain and activity level scores were summed and are presented as the mean \pm standard deviation. We also documented the date of the final assessment after the injury.

Interobserver Reliability and Clinical Practicability of the Classification System

In the present study, we developed a classification system to understand the parameters resulting in a poor clinical outcome. All plain radiographs and CT scans of our 5 patients were collected and numerated; the patient identification data were rendered anonymous. These plain radiographs and CT scans were evaluated by 2 observers. Observer 1 was an experienced trauma surgeon with a special interest in bone and joint orthopedic surgery. Observer 2 was a fellow for trauma surgery with a special interest in bone and joint surgery. Neither of the observers had any experience with the classification system before study onset to exclude the influence of training on reliability.

At the beginning of the present study, the classification system was provided to the observers in the German language. In addition, 1 of us (A.T.M.) gave a 15-minute presentation of the classification system. The data acquisition of the 2 observers occurred independently.

Statistical Analysis

The numerical data were analyzed using a computer software package for statistical analysis (SPSS, version 11.5; SPSS Inc., Chicago, IL). All values are reported as the mean \pm standard deviation. Statistical significance was determined using the Wilcoxon matched-pairs signed-ranks test and the Kruskal-Wallis equality-of-populations rank test for nonparametric samples at a confidence level of 95% ($p < .05$).

The percentage of agreement and interobserver reliability were assessed using the JMP statistical package, version 6 (SAS Institute, Cary, NC). For interobserver reliability, the kappa statistical function of the JMP statistical package was used to measure the kappa values to describe the agreement between observers and correct for the proportion that might have occurred by chance alone (22). A kappa value of 0 represented agreement by chance alone and kappa value of 1, perfect agreement. The kappa values were interpreted using the guidelines proposed by Landis and Koch (23). Values between 0.81 and 1 were considered to indicate excellent or almost perfect, 0.61 and 0.80 substantial, 0.41 and 0.60 moderate, 0.21 and 0.40 fair, and 0 and 0.20 slight reliability (23).

Results

Diagnosis and Clinical Outcomes

The medical database research resulted in 47 case reports of 55 patients with fractures, dislocations, or fracture-dislocations of the cuneonavicular joint line. These reports were augmented by our own 5 patients, for a total of 60 patients (5:1 male/female ratio, mean age 36 ± 12 years). To evaluate the clinical outcomes, we first analyzed the 55 cases from the published reports. Of the 55 cases, 43 were appropriate for evaluation in terms of postoperative pain and limitation of daily activities. The clinical outcome was assessed for a total of 48 patients (our 5 patients plus the 43 from the case reports). The mean follow-up period for these patients ranged from 12 to 20 months.

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