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The Incidence of Nonunion of the Naviculocuneiform Joint Arthrodesis: A Systematic Review

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ABSTRACT

Naviculocuneiform (NC) joint arthrodesis is an effective procedure to treat pain and provide stability to the medial column. Various forms of fixation have been described for NC arthrodesis. Despite this, the available literature is scant and questions remain regarding nonunion rate and contributory factors. A systematic review of the literature was undertaken to determine the rate of nonunion for NC joint arthrodesis. Seven studies involving 139 NC joint arthrodeses met inclusion criteria. The nonunion rate was 6.5% at a weighted mean follow-up of 73.2 months. There is insufficient evidence to provide a practice guideline based on the current literature. Adequately powered prospective clinical trials comparing well-matched patient groups with long-term follow-up are required to limit systematic error and enhance external validity. Specific outcomes measures should include union, functional assessment, complications, and cost-benefit analysis.

Arthrodesis of the naviculocuneiform (NC) joint is a surgical procedure first reported by Miller (1). This was described for the treatment of symptomatic flat feet in older children and adolescents. The indications for NC arthrodesis have since expanded to include degenerative arthritis, post-traumatic arthritis, medial column instability, pes planovalgus and pes cavus reconstruction, and Mueller-Weiss syndrome (2–6).

Methods of fixation for NC arthrodesis vary greatly. A recognized complication of NC arthrodesis is nonunion (7). Nonunion is a reported cause of failure of NC arthrodesis and can result in pain, edema, undesirable motion, fixation complications, continued disability, and requirement for revision surgery. To date, the reported incidence of nonunion remains inconsistent in the reported literature, ranging from 0% to 7% (8–10). A systematic review of electronic databases was performed to identify the rate of nonunion after NC arthrodesis.

Materials and Methods

We performed a systematic review of electronic databases and relevant peer-reviewed sources, including Embase, Cochrane, PubMed, and OvidSP Medline. We searched each identified study for pertinent references. Only those that involved NC joint arthrodesis were included.

Four electronic databases, including Embase (http://www.embase.com/), Cochrane Database of Systematic Reviews (http://www.cochranelibrary.com/), PubMed (https://www.ncbi.nlm.nih.gov/pubmed/), and OvidSP Medline (http://ovidsp.tx.ovid.com/) were searched. No restrictions were placed on date or language. We performed the present systematic review in February and March, using an inclusive text word query "Naviculocuneiform" OR "navicular" OR "cuneiform" AND "nonunion" OR "union" OR "arthrodesis" OR "fusion" OR "complication" OR "outcome" OR "Hoke" OR "Miller," where the uppercase words represent the Boolean operators used. Each investigator reviewed all manuscripts with unanimous decision used for final inclusion. The references from identified manuscripts were then manually searched for additional potentially pertinent published works, which were then secured for review.

To acquire the highest quality and most relevant studies available, the publications were eligible for inclusion only if they involved skeletally mature patients undergoing NC joint arthrodesis without adjacent joint arthrodesis. Studies additionally required mean follow-up of at least 6 weeks and inclusion of appropriate detail regarding complications, nonunion rate, and patient demographics. If a reference could not be obtained through purchase, library assistance, or electronic mail contact with the author, it was excluded. Case reports and other articles with <5 reported cases were excluded. If the reference was not written in English, it was translated by the primary author (A.K.C.) from its native language to English using an Internet-based translator, specifically Google Translate (http://translate.google.com/). If a reference could not be translated, it was excluded.

Statistical analysis of the pooled data included the weighted mean, the associated range for the duration of follow-up, and patient age. The data were weighted as follows. For each sample size, the numeric results were summed and then divided by the total sample size for all included studies (eg, the weighted mean age was determined by taking the mean age for all patients in a study and multiplying it by the number of patients in the study and then repeating this for each study; the total

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number was then divided by the total number of patients and resulted in the weighted mean age). A statistical description of the pooled data was then compiled and is provided in the present report.

A complication was defined as dehiscence, infection, hardware complications, deep venous thrombosis or pulmonary embolus, recurrence, neurovascular injury, or malunion. A reoperation was defined as an unplanned operation subsequent to the initial arthrodesis that was aimed to address a complication. A revision was defined as a reattempt at NC arthrodesis.

The guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) were used to design our review of the literature. PRISMA is a 27-item checklist that is intended to improve review quality (11). This was supplemented by generating review quality scores. The methodologic quality of the included studies was assessed using the Coleman Score (12). A score of 100 indicates the highest-quality study with no confounding factors or other biases. One independent reviewer (M.D.W.) assessed the methodologic quality of the included studies.

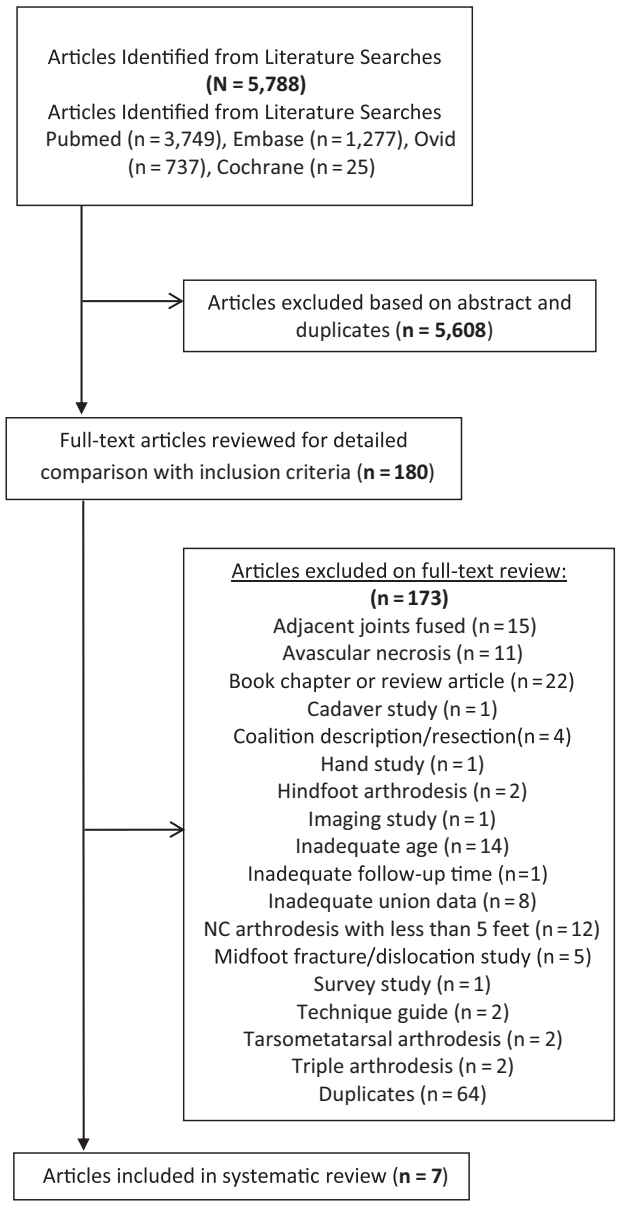

Fig. Flowchart of identified reports during the selection process.

Results

The search for potentially eligible information for inclusion in the systematic review yielded a total of 5788 manuscripts. All references identified were obtained and reviewed by each investigator in March 2018. After considering all potentially eligible references, 7 (0.001%) met our inclusion criteria (Fig.). Specifically, 2 retrospective comparative studies (Level III) and 5 retrospective case series (Level IV) met our inclusion criteria (8,13–18). A total of 94 patients with a weighted mean age of 44.2 years were included (Table 1). The most common indication for NC joint arthrodesis was pes cavus at 70.4% (69 of 98), followed by pes planus at 15.3% (15 of 98) and degenerative joint disease at 14.3% (14 of 98) (Table 2).

Of the 7 included articles, radiographically confirmed nonunion rate was 6.5% (n = 9 of 139 feet) at a weighted mean follow-up of 73.2 months (Table 1). For the studies that included it, the revision rate of nonunion was 4.2% (n = 2 of 48 feet) (Table 1) (8,15,17). For the studies that included it, the incidence of surgical wound dehiscence was 4.8% (n = 6 of 126) (8,14–17). The incidence of unplanned surgical removal of hardware was 8.8% (n = 5 of 57) (Table 3). The overall incidence of reoperation was 4% (n = 5 of 126), and the rate of infection was 1.5% (n = 2 of 134). The most common form of fixation that led to nonunion was staple fixation at 33.3% (n = 2 of 6) (Table 4). Combined staple and screw fixation yielded a nonunion rate of 0% (n = 0 of 2), combined screw and plate fixation yielded a nonunion rate of 2.3% (n = 1 of 43), and Kirschner wire fixation yielded a nonunion rate of 5.4% (n = 4 of 74) (Table 4). Of the 7 included studies, 3 specified the number of NC facets incorporated in the fusion. Of these 3 studies, 2 reported preparing all 3 NC articulations, and 1 reported preparing 2 NC articulations (Table 1) (8,14,15).

Two studies reported validated, functional outcome scores using the American Orthopaedic Foot and Ankle Society and Maryland Foot Scores (14,16). The methodologic quality of the included studies was generally poor. With regard to Coleman Score Appraisal of the included studies, 0 scored >70 (Table 5). The average Coleman score was 47.3 (range 39 to 63) (Table 5). There were 2 Level III studies and 5 Level IV studies (Table 1). There was heterogeneity in study type, fixation technique, indications for surgery, and study size among the included studies (Table 1).

Discussion

The reported incidence of nonunion remains inconsistent in the reported literature, ranging from 0% to 7% (8–10). The reported variability in nonunion rates can be attributed to differences in surgical indications, surgical technique, patient demographics, postoperative course, and sample size. The purpose of the present systematic review was to evaluate the incidence of nonunion after NC arthrodesis. Seven studies were identified that met the inclusion criteria (8,13–18). A review of the presented data allows for some generalized statements regarding arthrodesis of the NC joint. The incidence of nonunion is 6.5% at a weighted mean follow-up of 73.2 months.

The included references were either retrospective case series or retrospective comparative series, which are prone to selection bias. There was considerable variability and heterogeneity among included surgical techniques and reported outcome scores (Table 5). Additionally, subgroup or meta-analysis comparing incidence of nonunion among various fixation constructs lacked appropriate power to provide meaningful results. Because data are presented using weighted means and summed percentages, the results should be interpreted with caution.

Table 1
Demographic data included in the systematic review

Author (year)	Total Patients	Feet (no.)	Mean Age (years)	Fixation	Bone Graft	NC Joint	Intercuneiform	Additional Procedures	Follow-Up, Months (range)	Nonunion Rate (%)	Complications (%)	Revisions (%)
LaReaux and Hosey (1987) (13)	3	5	21	K-wire	None	NA	NA	Cuboid osteotomy, TAL	39.6 (10 to 72)	2 of 5 (40)	1 of 5 (20)	NA
Giannini et al (2002) (14)	39	69	36	K-wire	None	1,2,3	No	Cuboid osteotomy, plantar fasciotomy, Jones tenosuspension (14), hammertoe correction (9)	84 (24 to 180)	2 of 69 (2.9)	4 of 69 (5.8)	NA
Barg et al (2011) (15)	10	10	69.9	Screw + plate	None	1,2	No	STJ arthrodesis	18 (12 to 31.2)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)
Nemec et al (2011) (16)	9	9	Minimum 20	NA	NA	NA	NA	NA	70	1 of 9 (11.1)	4 of 9 (44.4)	NA
Verhoeven and Vandeputte (2012) (17)	5	5	65.6	NA	Cancellous autograft	NA	NA	None	Minimum 3	1 of 5 (20)	NA	1 of 5 (20)
Ajis and Geary (2014) (8)	28	33	54	Screw + plate	None	1,2,3	No	Cobb TA transfer (8), MDCO (2), GSR (7)	Minimum 3	1 of 33 (3)	2 of 33 (6.1)	1 of 33 (3)
Schipper et al (2018) (18)	NA	8	Minimum 19	Staple (6), staple + screw (2)	None	NA	NA	None	Minimum 12.4	2 of 8 (25)	NA	NA
Total	94	139	44.2						73.2	6.5%	8.7%	4.2%

Abbreviations: GSR, gastrocnemius recession; K-wire, Kirschner wire; MDCO, medial displacement calcaneal osteotomy; NA, not applicable; NC, naviculocuneiform; STL, subtalar joint; TA, tibialis anterior; TAL, tendon Achilles lengthening.

Table 2
Etiology and indication for the procedure

Author (year)	Pes Planus (%)	Pes Cavus (%)	Fracture (%)	Dislocation (%)	Tarsal Coalition (%)	Inflammatory Arthritis (%)	Post-Traumatic Arthritis (%)	Degenerative Joint Disease (%)
LaReaux and Hosey (1987) (13)	5 of 5 (100)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)
Giannini et al (2002) (14)	0 of 69 (0)	69 of 69 (100)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)
Barg et al (2011) (15)	10 of 10 (100)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)
Nemec et al (2011) (16)	0 of 9 (0)	0 of 9 (0)	0 of 9 (0)	0 of 9 (0)	0 of 9 (0)	0 of 9 (0)	0 of 9 (0)	9 of 9 (100)
Verhoeven and Vandeputte (2012) (17)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	0 of 5 (0)	5 of 5 (100)
Ajis and Geary (2014) (8)	NA	NA	0 of 33 (0)	0 of 33 (0)	0 of 33 (0)	NA	NA	NA
Schipper et al (2018) (18)	NA	NA	NA	NA	NA	NA	NA	NA
Total	15.3%	70.4%	0%	0%	0%	0%	0%	14.3%

Abbreviation: NA, not applicable.

Table 3
Complication and reoperation rate

Author (year)	Dehiscence (%)	Infection (%)	Hardware Complications (%)	DVT/PE (%)	Recurrence (%)	Malunion (%)	Nerve Injury (%)	CRPS (%)	Reoperation Rate (%)	Hardware Removal Rate (%)
LaReaux and Hosey (1987) (13)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Giannini et al (2002) (14)	4 of 69 (5.8)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	0 of 69 (0)	NA
Barg et al (2011) (15)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	1 of 10 (10)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)	0 of 10 (0)
Nemec et al (2011) (16)	0 of 9 (0)	0 of 9 (0)	4 of 9 (44.4)	NA	NA	NA	NA	NA	4 of 9 (44.4)	4 of 9 (44.4)
Verhoeven and Vandeputte (2012) (17)	0 of 5 (0)	0 of 5 (0)	1 of 5 (20)	NA	NA	NA	NA	1 of 5 (20)	1 of 5 (20)	1 of 5 (20)
Ajis and Geary (2014) (8)	2 of 33 (6.1)	2 of 33 (6.1)	0 of 33 (0)	0 of 33 (0)	NA	0 of 33 (0)	0 of 33 (0)	0 of 33 (0)	0 of 33 (0)	0 of 33 (0)
Schipper et al (2018) (18)	NA	0 of 8 (0)	NA	NA	NA	NA	NA	NA	NA	NA
Total	4.8%	1.5%	4%	0.0%	1.3%	0.0%	0.0%	0.9%	4%	8.8%

Abbreviations: CRPS, complex regional pain syndrome; DVT/PE, deep vein thrombosis/pulmonary embolism; NA, not applicable.

Table 4
Nonunion rate according to fixation type

CRPS	Nonunion Rate	%
K-wire (2 articles)	4 of 74	5.4%
Screw + plate (2 articles)	1 of 43	2.3%
Staple (1 article)	2 of 6	33.3%
Staple + screw (1 article)	0 of 2	0%
Unspecified (2 articles)	2 of 14	14.3%
Total	9 of 139	6.5%

Abbreviations: CRPS, complex regional pain syndrome; K-wire, Kirschner wire.

Plain radiographs are commonly used to assess union of arthrodesis; however, they have been shown to be of limited capacity in determining osseous union (19). In practice, clinical evaluation is essential and incorporates an assessment of pain, tenderness, and inability to bear weight. Details of these factors were not presented in the reviewed studies. Furthermore, the definition of nonunion was not standardized in the included reports (8,13–18).

Weaknesses of the present study are acknowledged. The search for references for inclusion was performed using electronic databases. Although relevant peer-reviewed journals were also manually searched, it is possible that not all pertinent references were identified by our methods. The inclusion criteria for our study included only articles written in the English language or those that could be easily translated. This may have excluded studies that could have otherwise affected our conclusions, and it may have given bias against research emanating from non-English-speaking countries. Only published data are included in this trial, and thus our conclusions must be interpreted in light of the publication bias. In clinical practice, NC joint arthrodesis may be less efficacious than it would appear in this review owing to unsatisfactory results possibly being less likely to be published, and to the fact that multiple, large published retrospective (or prospective) reports of consecutive patients germane to this topic do not exist. In conjunction with the paucity of high-quality evidence regarding clinical and functional outcomes, practical concerns still exist regarding optimal preparation fixation technique and surgical indications.

Strengths of this study include unanimous agreement regarding included studies and inclusion criteria. There is clarity and reproducibility of our search strategy using multiple evidence-based databases. PRISMA guidelines for the reporting of systematic reviews were used throughout to increase transparency and reduce the risk of publication bias (11). The mean follow-up time of 73.2 months is of clinical importance. Last, there are no previous guidelines or meta-analyses to determine the nonunion rate of NC joint arthrodesis. Thus, the current systematic review is the first study to address this gap in knowledge.

In conclusion, our pooled results demonstrate that NC joint arthrodesis remains a useful procedure to manage various foot deformities and arthritic conditions with acceptable nonunion and complication rates. The identified weighted nonunion rate is 6.5% at a weighted mean follow-up of 73.2 months for NC joint arthrodesis. Further research is warranted, including methodologically sound, appropriately powered prospective cohort studies focusing on long-term outcomes comparing joint preparation techniques and fixation constructs. There is a need to standardize the reporting of patient-reported outcomes. Additional outcome measures should include union rates, functional assessment, complications, and cost-benefit analysis. The evidence in the current literature precludes strong recommendations with regard any singular fixation construct, number of NC articulations prepared, or surgical technique.

Table 5
Coleman Score

	LaReaux and Hosey (1987)	Giannini et al (2002)	Barg et al (2011)	Nemec et al (2011)	Verhoeven and Vandeputte (2012)	Ajis and Geary (2014)	Schipper et al (2018)
Part A							
1. Study size	0	4	0	0	0	0	0
2. Mean f/u	3	5	0	3	0	0	0
3. % f/u	0	5	5	5	5	5	3
4. No. of interventions	0	0	10	0	0	0	5
5. Type of study	0	0	0	0	0	0	0
6. Diagnostic certainty	**0**	0	0	**5**	5	0	**5**
7. Description of technique	3	3	5	5	3	5	3
8. Description of postop rehab	3	5	5	5	5	5	5
Part B							
1. Outcome criteria	5	10	2	10	4	2	4
2. Procedure for assessing outcomes	15	15	9	15	9	9	9
3. Description of subject selection process	10	0	15	15	10	15	15
Total score	39	47	51	63	41	41	49

Abbreviations: f/u, follow-up; postop, postoperative; rehab, rehabilitation.

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