

## INTRODUCTION:

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

## MATERIALS AND METHODS:

A systematic review of electronic databases containing articles involving NC joint arthrodesis was performed. Four electronic databases (EMBASE, Cochrane, Pubmed, OvidSP Medline) were searched in March 2018. The systematic review was performed using the 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 Boolean operators. There was no restriction placed on date or language. All manuscripts were reviewed and manuscripts were included with unanimous agreement amongst investigators. Inclusion criteria required studies including patient undergoing NC arthrodesis with a mean follow-up of six weeks and published detail regarding complications, nonunion rates, and patient demographics. Case reports and other articles with less than 5 reported cases were excluded.

Fixation Type	Non-union Rate (%)
K-wire (2 articles)	4/74 (5.4)
Screw + Plate (2 articles)	1/43 (2.3)
Staple (1 article)	2/6 (33.3)
Staple + Screw (1 article)	0/2 (0.0)
Unspecified (2 articles)	2/14 (14.3)
<b>Total</b>	<b>9/139 (6.5)</b>

Table 2- Nonunion rate according to fixation type

Author (year)	Total Patients	Feet (N)	Mean Age (yr)	Fixation	NC joint	Intercuneiform	Follow-up (mo) [range]	Non-union Rate (%)	Complications (%)	Revisions (%)
LaReaux (1987)	3	5	21	K-wire	N/A	N/A	39.6 [10-72]	2/5 (40.0)	1/5 (20.0)	N/A
Giannini (2002)	39	69	36	K-wire	1, 2, 3	No	84 [24-180]	2/69 (2.9)	4/69 (5.8)	N/A
Barg (2011)	10	10	69.9	Screws + Plate	1, 2	No	18 [12-31.2]	0/10 (0.0)	0/10 (0.0)	0/10 (0.0)
Nemec (2011)	9	9	Minimum 20	N/A	N/A	N/A	70	1/9 (11.1)	4/9 (44.4)	N/A
Verhoeven (2012)	5	5	65.6	N/A	N/A	N/A	Minimum 3	1/5 (20.0)	N/A	1/5 (20.0)
Ajjs (2014)	28	33	54	Screw + Plate	1, 2, 3	No	Minimum 3	1/33 (3.0)	2/33 (6.1)	1/33 (3.0)
Schipper (2018)	N/A	8	Minimum 19	Staple (6), Staple + Screw (2)	N/A	N/A	Minimum 12.4	2/8 (25.0)	N/A	N/A
<b>Total</b>	<b>94</b>	<b>139</b>	<b>44.2</b>				<b>73.2</b>	<b>6.5%</b>	<b>8.7%</b>	<b>4.2%</b>

Table 1- Demographic Data included in Systematic Review

## RESULTS:

The search for potentially eligible information for inclusion in the systematic review yielded a total of 5,788 manuscripts. All references identified were obtained and reviewed by each investigator in March 2018. After considering all the potentially eligible references, seven (0.001%) met our inclusion criteria (Figure 1). Specifically, two retrospective comparative studies (Level III) and five 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, were included (Table 1). Out of the seven included articles, radiographically confirmed nonunion rate was 6.5% (n=9/139 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=2/48 feet) (Table 1) (8,15,17).

The incidence of unplanned surgical removal of hardware occurred was 8.8% (n= 5/57) (Table 3). The overall incidence of reoperation was 4.0% (n=5/126) and rate of infection was 1.5% (n=2/134). The most common form of fixation that led to nonunion was staple fixation at 33.3% (n=2/6) (Table 2). Combined staple and screw fixation yielded a nonunion rate of 0% (n=0/2), combined screw and plate fixation yielded a nonunion rate of 2.3% (n=1/43), and K-wire fixation yielded a nonunion rate of 5.4% (n=4/74) (Table 2). Of the seven included studies, three specified the number of naviculocuneiform facets incorporated in the fusion. Of these three studies, two reported preparing all three naviculocuneiform articulations and one reported preparing two naviculocuneiform articulations. (Table 1) (8,14-15).

Two studies reported validated, functional outcome scores using the AOFAS and Maryland Foot Scores (14,16). The methodological quality of the included studies was generally poor. There were two level III studies and five 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).

Author (year)	Dehiscence (%)	Infection (%)	Hardware Complications (%)	DVT/PE (%)	Recurrence (%)	Malunion (%)	Nerve Injury (%)	CRPS (%)	Reoperation in Feet (%)	Hardware Removal Rate (%)
LaReaux (1987)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Giannini (2002)	4/69 (5.8)	0/69 (0.0)	0/69 (0.0)	0/69 (0.0)	0/69 (0.0)	0/69 (0.0)	0/69 (0.0)	0/69 (0.0)	0/69 (0.0)	N/A
Barg (2011)	0/10 (0.0)	0/10 (0.0)	0/10 (0.0)	0/10 (0.0)	1/10 (10.0)	0/10 (0.0)	0/10 (0.0)	0/10 (0.0)	0/10 (0.0)	0/10 (0.0)
Nemec (2011)	0/9 (0.0)	0/9 (0.0)	4/9 (44.4)	N/A	N/A	N/A	N/A	N/A	4/9 (44.4)	4/9 (44.4)
Verhoeven (2012)	0/5 (0.0)	0/5 (0.0)	1/5 (20.0)	N/A	N/A	N/A	N/A	1/5 (20.0)	1/5 (20.0)	1/5 (20.0)
Ajjs (2014)	2/33 (6.1)	2/33 (6.1)	0/33 (0.0)	0/33 (0.0)	N/A	0/33 (0.0)	0/33 (0.0)	0/33 (0.0)	0/33 (0.0)	0/33 (0.0)
Schipper (2018)	N/A	0/8 (0.0)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
<b>Total</b>	<b>4.8%</b>	<b>1.5%</b>	<b>4.0%</b>	<b>0.0%</b>	<b>1.3%</b>	<b>0.0%</b>	<b>0.0%</b>	<b>0.9%</b>	<b>4.0%</b>	<b>8.8%</b>

Table 3- Complication and Reoperation Rate

## DISCUSSION:

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 non-union is 6.5% at a weighted mean follow-up of 73.2 months.

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. 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.

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