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A Novel Technique of Talo-Cuneiform Arthrodesis Using Metallic Cage in Navicular Avascular Necrosis: A Short-term Retrospective Cohort Study of Three Cases

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Abstract

Background: Avascular necrosis (AVN) of the navicular is a rare but debilitating condition that frequently results in collapse of the medial column and extensive bone loss in later stages. These structural deficits pose a major challenge for achieving reliable fusion with conventional techniques using just bone graft. This study dwells into the use of metallic cage to achieve talo-cuneiform arthrodesis as an alternative to conventional techniques allowing restoration of medial column alignment, maintenance of length, and provision of stable support to facilitate union in cases with substantial osseous defects.

Materials and Methods: This is a clinical, retrospective study, conducted at our institution from March 2021 to March 2024 on 3 patients with AVN of navicular. Diagnosis was made on radiographs and/or magnetic resonance imaging as well as clinical examination. Surgical fixation was individualized with the use of titanium metallic cages to fill the osseous defect and patients followed up for a mean period of 50 weeks (range: 49–50 weeks). Functional outcome was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) score as well as Foot and Ankle Outcome Score (FAOS). Radiological stability was assessed using weight-bearing radiographs on follow-up visits.

Results: The mean AOFAS, FAOS score improved from 48.7 and 42.3 preoperatively to 84.7 and 86 postoperatively indicating a significant improvement ($P < 0.05$) in functional outcomes. All patients had stable plantigrade foot and radiological stability after a mean 50 weeks follow-up.

Conclusion: The combination of titanium cages, autologous bone grafts, and angular stable screw-plate systems appears to offer a promising alternative to conventional surgical techniques for managing navicular AVN. This method ensures medial column length preservation and provides a stable environment for arthrodesis. Based on our study, we believe that this approach could be more effective than traditional methods, offering a better prognosis for patients with idiopathic AVN (Muller–Weiss syndrome), post-traumatic arthritis, or large bone defects following navicular neoplasm resection.

Keywords: Avascular necrosis of navicular, Navicular neoplasm, Talo-cuneiform arthrodesis, Muller–Weiss syndrome, Osseous defect.

Introduction

Navicular osteonecrosis can arise due to various pathologies such as trauma, infection, neoplasm, and idiopathic avascular necrosis (AVN) [1, 2, 3]. All pathologies eventually lead to osteonecrosis due to vascular insult to the peculiar blood supply of the navicular. The medial and lateral sides of the navicular are well vascularized by the branches of the dorsalis pedis and posterior tibial arteries, leaving the central portion of the navicular prone to AVN, which may eventually lead to arthritis of the talo-navicular and naviculocuneiform joints [4]. These patients usually present with difficulty in ambulation, pain, and swelling over the midfoot region. Treatment modalities range from non-operative to operative interventions. Non-operative treatment, though beneficial at the start, often fails, and patients require operative management at later stages [5]. Operative techniques include percutaneous drilling and decompression, talo-navicular arthrodesis, talo-cuneiform arthrodesis, triple

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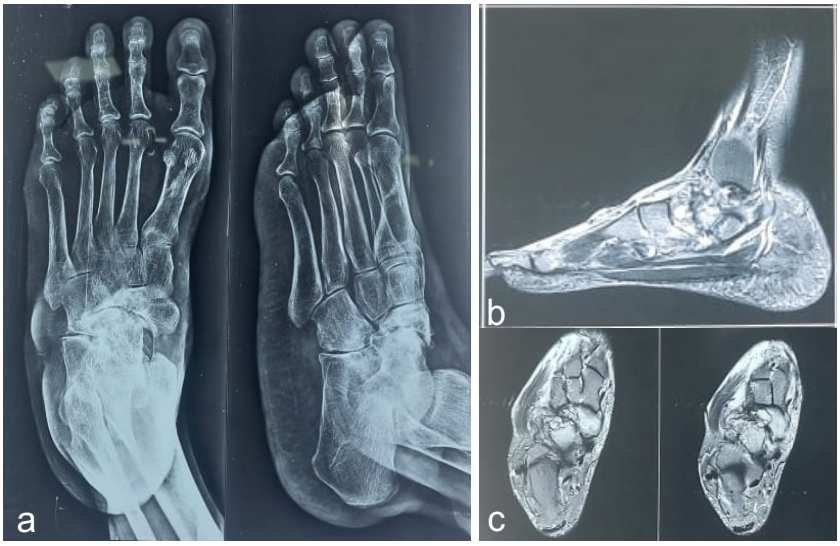

Figure 1: 1A: Radiograph showing avascular necrosis of navicular bone. Fig 1B,C: MRI showing avascular necrosis of navicular bone

(subtalar and midtarsal joints) arthrodesis, and navicular replacement [5, 6]. However, there is no general consensus on the optimal surgical treatment. Treatment modalities are often complex and may require excessive bony resection with length-maintaining arthrodesis and grafts. Furthermore, large bone defects following excessive resection may lead to complications like non-union, thereby significantly affecting the quality of life [7].

The use of 3D-printed implants has, therefore, gained popularity, providing a more patient-specific approach for the treatment of these complex pathologies. However, low cost-effectiveness for the general population in developing countries makes it a less feasible option [8]. This case series demonstrates an alternative and cost-effective approach for addressing huge osseous defects following navicular AVN. In this study, navicular excision was performed in all patients and replaced with titanium cages, which are generally used in spinal surgeries. Bone grafts were harvested and filled inside the cage, and the construct was further stabilized with plates and screws. The cage construct maintains the medial column length, preventing collapse, with bone grafts providing the necessary scaffold for arthrodesis. A total of three patients were managed with this approach and followed up for a minimum of 50 weeks.

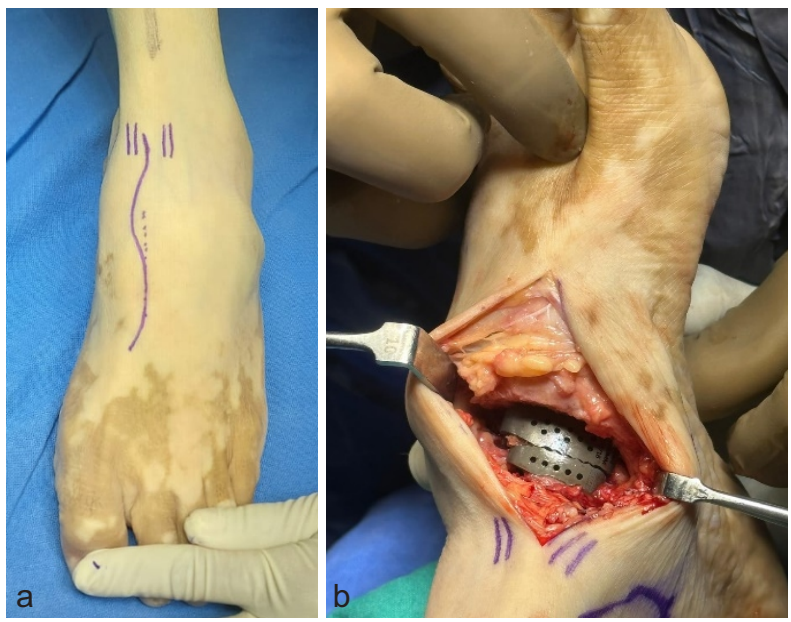

Figure 2: 2A: Skin incision between the tibialis anterior and extensor hallucis longus, 2B: Titanium cage inserted in pressed fit manner

Materials and Methods

This is a clinical, retrospective study carried out at our institution. From March 2021 to March 2024, a total of 3 patients (two females and one male) with mean age of 40.6 years with AVN of the navicular bone underwent surgery with all the necessary consents using titanium cage filled with autologous bone graft further supplemented with plates and screws. The diagnosis was made after clinical and radiological evaluation of the patients. A detailed medical history of all patients was noted. Radiological evaluation with radiographs was performed for diagnosis, and magnetic resonance imaging (MRI) was used when needed. Patients were followed up postoperatively at regular intervals. The American Orthopaedic Foot and Ankle Society (AOFAS) score and Foot and Ankle Outcome Score (FAOS) were used for functional evaluation. Radiological assessment was done using weight-bearing radiographs on follow-up visits. All patients consented for use of their radiographs and clinical image in our study.

Inclusion criteria

Adult AVN of navicular arising due to:

- Idiopathic avascular navicular necrosis (Muller–Weiss Syndrome)
- Post-traumatic cause
- Navicular neoplasm.

Exclusion criteria

- Active infections/osteomyelitis
- Adjacent joint involvement
- Kohler's disease (pediatric navicular AVN)

Variables

Variables included in the study are age, gender, comorbidities, and defect size. Data were collected

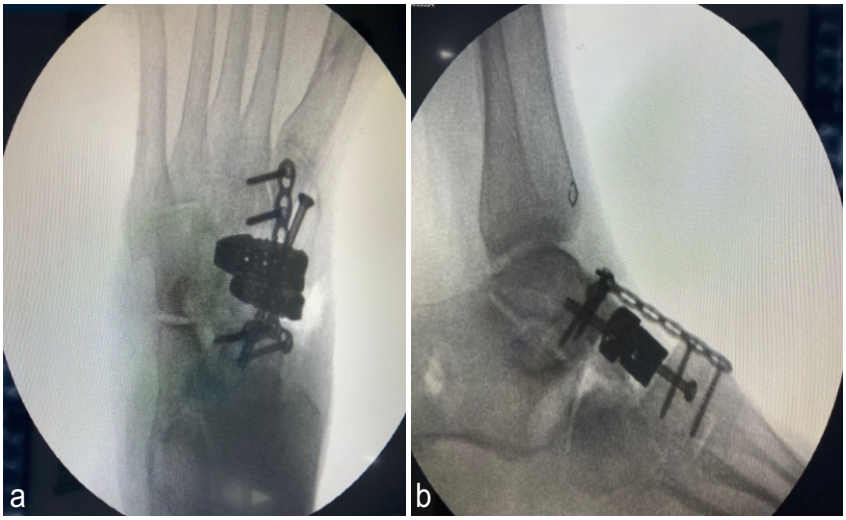

Figure 3: 3A,3B: Intra operative fluoroscopy imaging of anteroposterior and lateral views showing pressed fit navicular cage with cancellous screws and a bridge plate.

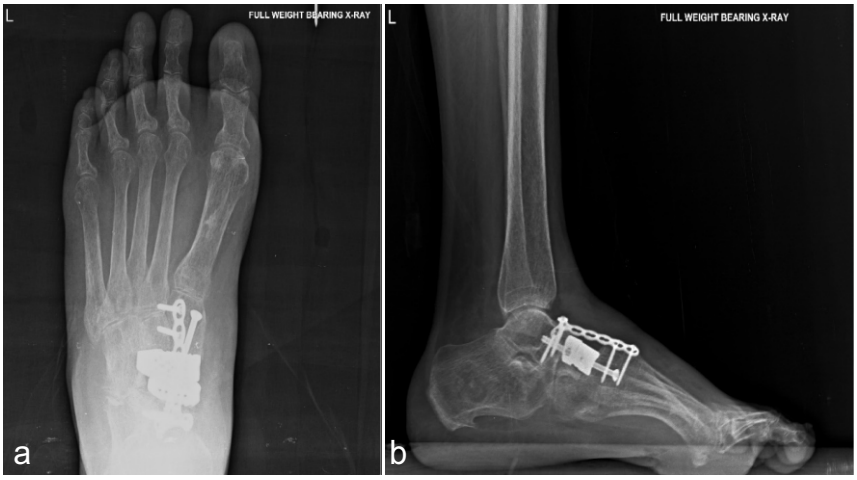

Figure 4: 4A,4B: 49 weeks follow up weight bearing radiographs of anteroposterior and lateral views showing no medial column shortening, maintained Meary's angle (Talo-1st metatarsal angle), well donor site healing, no secondary deformity.

Figure 5: 5A,5B: Image showing plantigrade foot with no visible secondary deformity

on the surgical treatment, follow-up, functional outcome using AOFAS and FAOS score, and associated complications if any.

Outcome measures

Outcome measures included clinical evaluation of patient using AOFAS and FAOS score and radiological stability on weight-bearing radiographs. Patients were assessed for any complaints of chronic pain, instability, or difficulty in weight-bearing on subsequent follow-ups. (Table 1, Fig 1-15).

All patients presented clinically with pain over the midfoot region since approximately 5 months on average (range: 4–6 months). On palpation, tenderness was elicited over the navicular bone and Chopart joint movements were painful and restricted. There was no history of fever, weight loss, or any other constitutional symptoms. Diagnosis was weight on weight-bearing foot radiographs and/or MRI. All cases were operated by the same senior orthopedic surgeon. Intraoperatively, a huge osseous defect was found in all the cases as mentioned in Table 1. Titanium metallic cage filled with autologous calcaneal graft was used to fill the defect and further stabilized with plates and screws. Intraoperatively, Meary's angle (Talo-1st metatarsal axis angle) was assessed with simulated weight-bearing stress fluoroscopy. The final titanium cage size was selected accordingly after assessing the Meary's angle. Functional assessment with AOFAS and FAOS score and radiological assessment with weight-bearing foot radiographs was done till the final follow-up at mean 50 weeks (range: 49–50 weeks).

Surgical technique

Surgical intervention was carried out under spinal anesthesia with the patient in a supine position. Prepping and draping were done under all aseptic precautions, and a tourniquet was used. All patients were operated by the same senior orthopedic surgeon. A dorso-medial incision was made, centered over the navicular bone, extending from the talo-navicular to the naviculocuneiform joint (Fig. 2a). The extensor hallucis longus tendon was

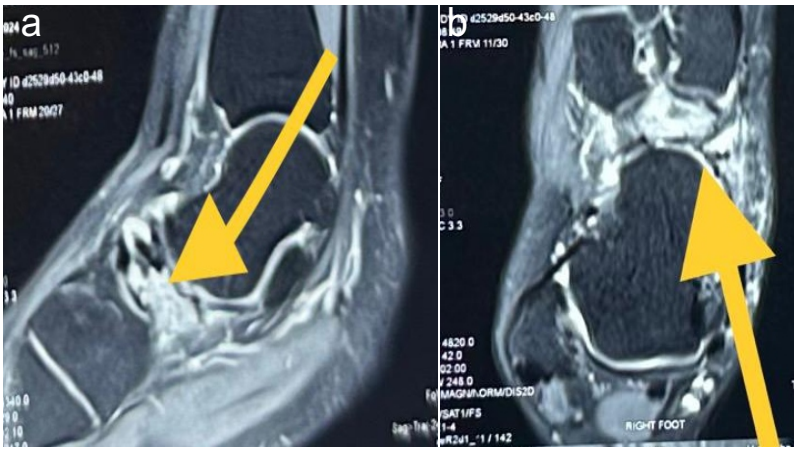

Figure 6: 6A, 6B: MRI of right foot showing recurrence of giant cell tumor of navicular bone

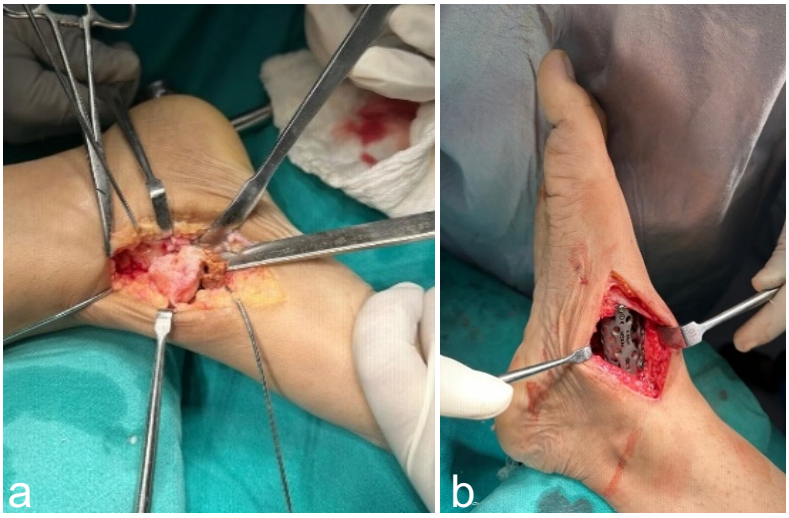

Figure 7: 7A: Image showing excision of diseased navicular 7B: Pressed fit navicular cage inserted in the defect.

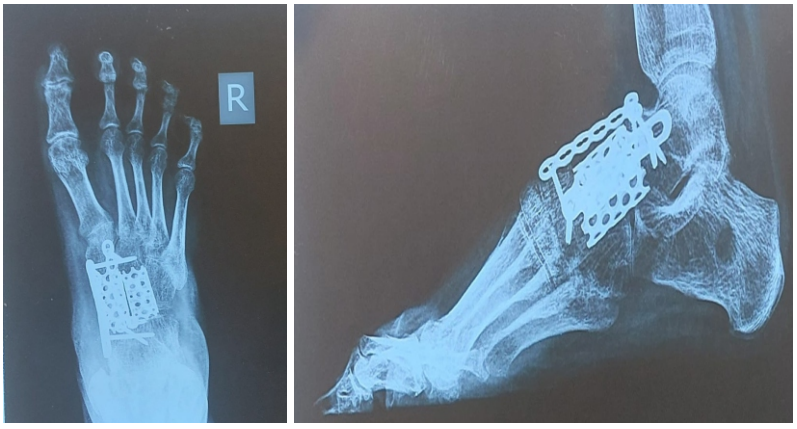

Figure 8: 8A, 8B: Immediate post operative fluroscopy of anteroposterior and lateral views showing pressed fit navicular cages with Talonaviculocuneiform arthrodesis done using 2 bridge plates.

retracted laterally, and subperiosteal dissection was carried out over the dorsal talus, navicular, and cuneiform. The diseased navicular bone was excised, and the talo-navicular and naviculocuneiform joint cartilage was denuded. The defect created was measured, and a titanium cage of appropriate size was selected. Bone graft was harvested from the calcaneus in all the cases A titanium cage filled with bone graft was used to fill the navicular defect (Fig. 2b and 7b). Cancellous screws (4 mm) were used for compression in cases 1 and 3, passed through the cage from the talus to the cuneiform over a guide pin. A supporting neutralization plate with a 2.7 mm construct was used in all cases applied through the same incision either medially or dorsomedially. After final fixation, fluoroscopy was used to assess the alignment in anteroposterior and lateral views. After closure of the skin and soft tissue, a sterile dressing was applied, and the patient was immobilized in a below-knee splint for a period of 6 weeks.

Postoperative protocol

All patients were put on a non-weight-bearing protocol for 6 weeks with a below-knee posterior splint. Suture removal was done at the end of 4 weeks as per hospital protocol. All patients were encouraged to perform active toe movements from the 1st day. After 6 weeks, partial weight-bearing with toe walking was started. At the end of 3 months, all patients were able to bear full weight on the operated leg. All patients were followed for a minimum period of 1 year (mean 50 weeks)

Results

From March 2021 to March 2024, a total of 3 patients (Two females, one male) were operated on. The mean age at the time of surgery was 40.6 years (range: 26–52 years). The mean AOFAS was found to be 48.7 preoperatively (range: 42–56) and 84.7 postoperatively (range: 83–87). The FAOS score improved from 42.3 preoperatively (range: 37–48) to 86 post-operatively (range: 85–88). $P < 0.05$ was statistically significant showing good functional improvement The Meary's angle was well maintained on weight-bearing radiographs at the last follow-up showing good radiological stability. Delayed wound healing was the only complication noted in case no 1 which resolved after 2 weeks of conservative treatment (Table 2).

Figure 9: 9A, 9B: 50 weeks follow up fluoroscopy showing no medial column shortening, maintained Meary's angle, well donor site healing, no secondary deformity

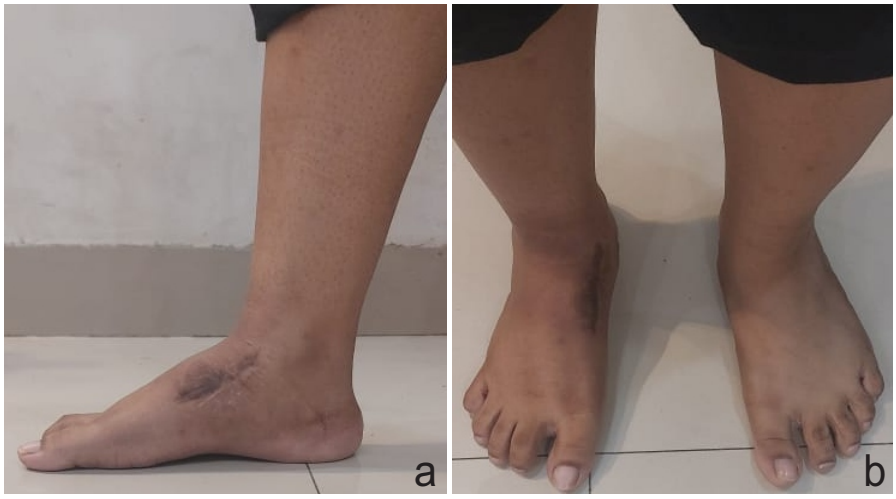

Figure 10: 10A, 10B: 50 weeks follow up clinical images of plantigrade foot with no secondary deformity

Figure 11: 11 A, B: Anteroposterior and lateral radiographs showing hardware failure with reduced navicular bone stock.

Discussion

AVN of the navicular bone is a challenging condition due to the unique anatomical and vascular characteristics of the bone. The navicular receives its blood supply from small end-arterial branches with limited collateralization, making it particularly susceptible to ischemic insult. Vascular compromise, repetitive mechanical overload, trauma, neoplasms, or idiopathic vascular failure can initiate a cascade of bone ischemia, fragmentation, and collapse, ultimately leading to secondary arthritic changes in the talo-navicular and adjacent joints [1, 2, 3, 4]. Muller–Weiss disease (MWD) or idiopathic navicular AVN represents the adult form of spontaneous osteonecrosis of the navicular, usually affecting middle-aged individuals. It is characterized by lateral collapse and fragmentation of the navicular with subsequent talo-navicular incongruity. Although the etiology remains debated, vascular insufficiency, abnormal biomechanics, and altered ossification patterns are implicated [1, 9]. Patients with navicular AVN usually present with chronic midfoot pain with associated flattened or low medial arch. Examination often reveals tenderness over the talo-navicular joint, restriction of motion with either forefoot adduction or varus in advanced stages [2, 3]. (Chart 1).

Conservative management such as activity modification, immobilization, non-steroidal anti-inflammatory drugs, and custom orthoses remain the first-line approach in early stages with mild symptoms [4]. For mild-to-moderate collapse joint, preserving procedures such as core decompression, drilling, and vascularized bone grafting have been described to restore blood supply and preserve the navicular. Recent reports highlight the use of vascularized medial femoral condyle flaps with encouraging early outcomes [10]. Arthrodesis procedures such as talo-navicular arthrodesis, naviculocuneiform fusion, or extended triple arthrodesis are the

Figure 12: Osseous void after excision of diseased navicular

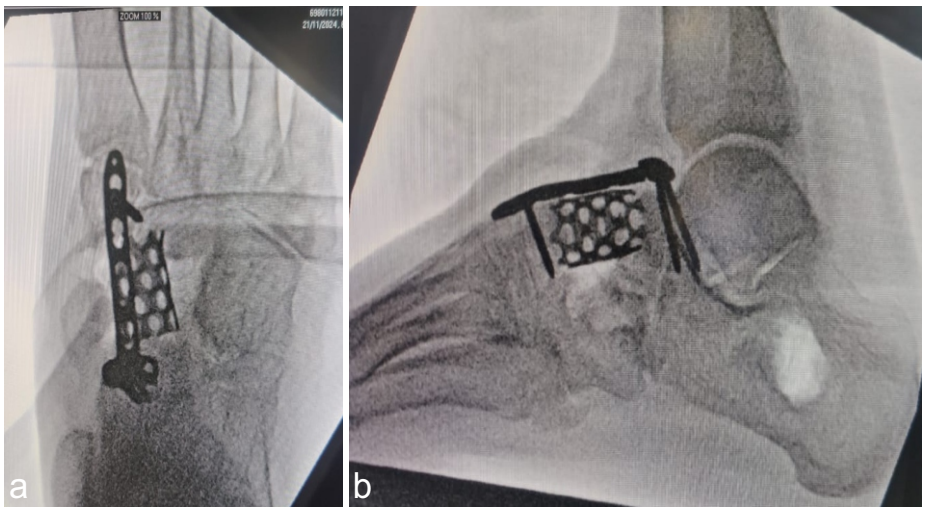

Figure 13: A, B: Intra-operative fluoroscopy of anteroposterior and lateral views showing pressed fit navicular cages with talo-cuneiform arthrodesis done using a bridge plate.

Figure 14: A, B: 50 weeks post-operative weight bearing radiographs showing no medial column shortening, well donor site healing, no secondary deformity. Meary's angle of approximately 6 degrees seen on lateral view which was comparable to the contralateral side.

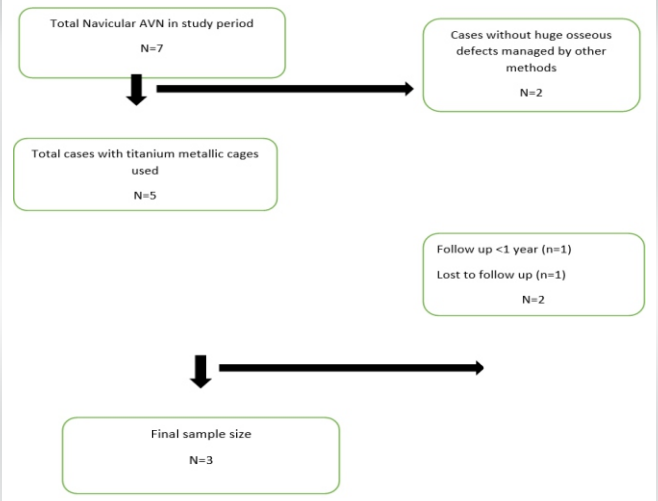

Chart 1: Flow chart of total patient selection (n = 3).

mainstay for advanced cases with higher collapse and secondary arthritis. Fusion provides pain relief and restores alignment, though at the cost of restricted motion [11]. However, all the recent articles show that talo-cuneiform arthrodesis shows the best clinical outcome among all other procedures [11, 12, 13].

In severe bone collapse and advanced arthritis, a large osseous defect may occur post excision of de-vascularized bone. Similarly, in our case series, a large osseous defect was seen post debridement and excision of de-vascularized navicular bone. Management of such huge defects posts a serious challenge. A study by So et al. [14] states that autografts and allografts tend to undergo late collapse as these options are not designed to withstand high loads of the foot and the ankle. This can lead to hardware failure and graft collapse in long-term follow-ups, as shown in recent studies [14, 15]. Thus, a length maintaining implant to provide both structural and biological support is necessary for providing good long-term functional outcome. Hence, 3D custom-made titanium implants are gaining popularity but cost constraints in developing countries limits their use [8].

Titanium cage implants are used frequently in spine surgeries and are readily available in developing countries such as ours and can be useful in foot and ankle surgeries for management of huge osseous defects. A case series by Bulut et al. [16] showed that lower limb osseous defects can be effectively managed with titanium cages where traditional methods may be inefficient. The advantage is that the titanium cages help maintain the

Table 1: Summary of all three cases

Case	Age/ Sex	Diagnosis	Investigation done	Defect size after excision of avascular bone	Treatment method	Final Follow-up	Comorbidity	Figures
1	52/F	Muller–Weiss syndrome	Weight-bearing foot radiographs MRI	4×6 cm	Titanium cage filled with autologous calcaneal bone graft and stabilized with plate and screws	49 weeks	None	1a, b, c 2a and b 3a and b 4a and b 5a and b
2	26/F	Recurrent navicular giant cell tumor previously operated outside	MRI	6×5.5 cm	2 Titanium cages filled with autologous calcaneal bone graft and stabilized with 2 plates and screws	50 weeks	None	6a and b 7a and b 8a and b 9a and b 10a and b
3	44/M	Previously operated case of navicular fracture with navicular avascular necrosis	Weight-bearing foot radiographs	2×4 cm	Titanium cage filled with autologous calcaneal bone graft and stabilized with plate and screws	50 weeks	None	11a and b 12 13a and b 14a and b 15a and b

Figure 15: A, B: 50 weeks follow up clinical images of plantigrade foot with no secondary deformity

Table 2: Table showing improvement in pre- and post-operative AOFAS and FAOS score

Parameters	Case 1	Case 2	Case 3	Mean±SD	*P*-value
Age	52	26	44	40.6 ± 13.3	0.0064 (<0.05)
AOFAS pre-operatively	56	42	48	48.7 ± 7.0	
AOFAS post-operatively	87	83	84	84.7 ± 2.1	0.0029 (<0.05)
FAOS pre-operatively	37	48	42	42.3 ± 5.5	
FAOS post-operatively	88	85	85	86 ± 1.7	
Complications	Delayed wound healing	None	None		

AOFAS: American Orthopedic Foot and Ankle Society, FAOS: Foot and Ankle Outcome Score

structural integrity thereby preventing collapse and can even provide a biological support to achieve bony arthrodesis as also shown in studies by Patil et al. [17] and Noble et al. [18]. In our case study, the need for autograft was significantly less due to the use of titanium metallic cage, thereby reducing the risk of donor site morbidity. Graft was harvested locally from calcaneus, filled inside the cage which was then inserted in press fit manner. This ensured better compression at the site, reducing the risk of post-operative collapse. The talo-cuneiform arthrodesis had a bone (talus)-bone (graft filled cage)-bone (cuneiform) interface, thereby facilitating bony union. None of our patients experienced non-union, secondary deformity, medial column shortening, or donor site complications after their end of follow-up period.

A comparison of our study with other articles with talo-cuneiform arthrodesis reveals comparable functional outcome (Table 3). P < 0.05 showed significant improvement from pre-operative to post-operative functional score. Similarly, all patients had radiological stability on weight-bearing foot radiographs with maintained Meary's angle on their final follow-up.

Limitations of our study include a relatively small sample size of three patients and a short follow-up of approximately 1 year. Long-term follow-up may lead to additional investigations about the degeneration of

Table 3: Comparison of our study with recent studies on talo-cuneiform arthrodesis for navicular AVN

Articles	Maximum follow-up	Complications	AOFAS interpretation
Uzer, *et al* . 2024 (*n* = 12) [19]	35 months	1 non-union	85 (good)
Bai, *et al* . 2023 (*n* = 15) [13]	5 years	-	91 (excellent)
Cao *et al* . 2017 (*n* = 16) [20]	1 year	1 hardware failure	90.1 (excellent)
Our study (*n* = 3)	1 year	-	84.7 (good)

adjacent joints and subsequent bony consolidation. Cooperation between several clinical centers will be necessary to expand the study pool and analyze the results statistically. Clinical relevance of this study lies in the fact that it can form the basis for further studies in management of osseous defects arising out of navicular pathology with the use of titanium metallic cage as an alternative to traditional less effective methods.

Conclusion

There is no consensus on the surgical treatment for AVN and subsequent osteoarthritis of talo-navicular and naviculocuneiform joints. Often time, it leads to large osseous defects after excision of the diseased bone. The goals of the surgical treatment are to achieve a pain free, plantigrade, and well-aligned foot and for that reason the assessment has to be personalized and specific for the patient treated. Based on our experience with the patients described in this article, we believe that the combination of the use of an angular stable screw-plate system with a bone graft filled titanium cage and emphasis of the restoration of the length of the medial column could achieve a better outcome than conventional techniques. We also believe that the results of our report could be useful in the development of future prospective cohort studies and randomized controlled trials that focus on the treatment of MWD, post-traumatic arthritis, and bony defects arising from removal of navicular neoplasm.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

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