

Efficacy of Triple and Talonavicular Arthrodesis for the Treatment of III-V Müller-Weiss Disease

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Müller-Weiss Disease (MWD) is a rare foot disease with unclear etiology but frequently occurred in women. Due to the resistance to conservative treatment, surgical therapy has gradually occupied a necessary position in the clinical management of MWD. Joint fusion surgery is a commonly used treatment for MWD, which could effectively alleviate pain, correct deformation, and restore function. A total of 12 MWD patients (III-V stage) were enrolled in this study. All patients showed no significant improvement in conservative treatment and further received the triple and talonavicular arthrodesis. All patients were followed up with an average follow-up of 16.8 ± 1.19 months (mean \pm SD). The triple and talonavicular arthrodesis significantly ameliorated the pain and walking dysfunction in the affected foot. The American Orthopedic Foot Andankle Society (AOFAS) scores dramatically increased from 43.4 ± 16.1 to 85.3 ± 6.2 . Meanwhile, the conducting of triple and talonavicular arthrodesis improved the X-ray length (15.5 ± 0.8 vs. 14.3 ± 0.9 cm) and arch height (18.6 ± 0.9 vs. 10.2 ± 0.7 mm) and reduced the Meary-Tomeno angle (1.3 ± 2.5 vs. $2.14 \pm 4.8^{\circ}$). The triple and talonavicular arthrodesis achieved a satisfying therapeutic effect on MWD patients at the III-V stage, which improved patients' outcomes and the quality of life.

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Introduction

Müller-Weiss Disease (MWD), also known as "adult scaphoid osteonecrosis", is a rare foot disease with unclear etiology and usually occurred in middle-aged and elderly women (Perisano et al. 2018). The typical symptom of MWD is the pain in the midfoot when weight-bearing, hindfoot varus, deformation of the medial longitudinal arch of the foot with swelling in the medial back of the foot (Maceira and Rochera 2004). As the high misdiagnosis rate, MWD usually developed into arthritis of the hindfoot and finally causes a paradoxical pes-planus deformity. Clinically, conservative treatments, such as short leg cast and hard insole, are suitable for the patients at early stages, but cannot alleviate disease development or attenuate the pain of the patients with an advanced stage (Monteagudo and Maceira 2019). Therefore, surgical therapy became the major therapeutical strategy. However, due to the lack of a gold standard for MWD, there is an urgent need to explore an effective way for its clinical management.

Joint fusion surgery is a reliable and effective treatment in the clinic for MWD patients failing conservative treatments, which significantly assuage pain, correct deformation, and restore function (Fernández de Retana et al. 2004; Yu et al. 2012). The joint fusion surgery can be conducted as talonavicular joint fusion, talar-navicular-wedge joint fusion, and triple fusion (Lopez et al. 2012; Qu et al. 2019). A previous study demonstrated the outstanding significance of 3-portal arthroscopic triple arthrodesis for the correction of severe flatfoot deformity and gave the operative details (Li and Lui 2020). In a six-case study, the performing of talonavicular joint arthrodesis made osteonecrosis-induced flatfoot patients develop bony fusion, indicating a successful intervention (Wang et al. 2012).

The present study focused on 12 MWD patients who had received conservative treatment over 3 months without

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significant improvement. The triple and talonavicular arthrodesis was performed. The operative intervention significantly improved the clinical outcome of MWD patients.

Methods

Inclusion and exclusion of patients

A total of 12 MWD patients were enrolled from March 2017 to March 2021 in the Department of Orthopedic Surgery, The First Affiliated Hospital of University of Science and Technology of China. This study was reviewed and approved by the Committee on Medical Ethics of The First Affiliated Hospital of University of Science and Technology of China Hospital, and all patients provided signed informed consent. The inclusion criteria were as follows: (a) Patients suffered from long-term chronic pain in the midfoot, which was worsened when weight bear, and accompanied by walking dysfunction; (b) Patients were diagnosed with swelling on the dorsal side of the navicular bone with local tenderness and lower arch collapse; (c) Patients had received conservative treatment and showed no significant improvement; (d) No abnormal results were observed in the blood routine test, C-reactive protein, and erythrocyte sedimentation rate; (e) X-ray examination showed comma-like deformation or partial fragmentation in the scaphoid bone, which was consistent with avascular necrosis.

Patients with the following diseases were excluded: Kohler disease, Charcot arthropathy, bone changes induced by metabolic or autoimmune disease (such as diabetes, rheumatoid arthritis, systemic lupus erythematosus, etc.), red swollen and ulceration in the skin of the foot, osteonecrosis in scaphoid bone induced by stress or ode fractures.

Therapeutic procedure

Patients were in a supine position with a pneumatic tourniquet on the thigh. The talonavicular or talus wedge joint fusion was conducted after the thorough loosening of the subtalar, calaneocubic, and talonavicular joints. The quadrilaterals were straightened out and the force line was corrected in order to restore the arch. The subtalar and calcanecubic joints were retained as much as possible. The fused position was transfixed with 4.0 mm cannulated screws and the fusion surface can be extended into the anterior subtalar joint.

The operated foot was protected with the cast for two months, and weight-bearing walking with a rocker boot was then allowed.

Follow-up survey

The included patients were followed-up at certain time points for 18 months after surgery with the physical examinations. The American Orthopedic Foot Andankle Society (AOFAS) midfoot scale (Kitaoka et al. 1994) of patients was evaluated in the final visit.

Radiographic assessment

The weight-bearing radiographs, including the lateral view, the anteroposterior view, and the hindfoot alignment view, were taken before the operation and during the last follow-up. The Meary-Tomenon angle was measured with the lateral view, and the foot length and the arch height were also measured from the radiographic results. Correlated parameters were measured and classified as previous reports (Aebi et al. 2017; Wong-Chung et al. 2021).

Statistical analysis

The data were represented as mean \pm SD and analyzed by paired student's t-test using SPSS 26.0 software. *p < 0.05 indicates statistical significance.

Results

Clinical results

The basic features of enrolled patients have been summarized in Table 1. The study subjects comprised 4 males and 8 females with an average age of 52.1 ± 9.2 years. According to the method Maceira, there were 7 patients diagnosed at III stage, 3 patients with IV stage, and 2 patients with V stage.

The average follow-up time of patients was 16.8 ± 1.19 months (ranged 12-18 months). The fusion therapy obviously ameliorated the pain and walking dysfunction in the affected foot. A favorable union was observed with a mean union time of 13.6 ± 1.24 weeks (range 12-16 weeks, Table 1). No incision infection or skin necrosis occurred after the surgery. The AOFAS of patients dramatically increased from 43.4 ± 16.1 to 85.3 ± 6.2 after 1 year of the fusion therapy. The X-ray length increased from 14.3 ± 0.9 to 15.5 ± 0.8 cm, and the arch height also improved to 18.6 ± 0.9 mm from 10.2 ± 0.7 mm. Moreover, the fusion therapy significantly reduced the Meary-Tomenon angle from 2.14 ± 4.8 to $1.3 \pm 2.5^{\circ}$ (p < 0.05, Table 1).

Typical case analysis

A 57-year-old female patient had suffered from pain in

Table 1. Basic features of Müller-Weiss Disease (MWD) patients before and after receiving fusion therapy.

	Pre-operation	Post-operation
Age (years)	52.1 ± 9.2	
Sex (M/F)	4/8	
Stage (III/IV/V)	7/3/2	
Follow up (months)	16.8 ± 1.19	
AOFAS score	43.4 ± 16.1	$85.3\pm6.2\texttt{*}$
X-ray foot length (cm)	14.3 ± 0.9	$15.5\pm0.8*$
Arch height (mm)	10.2 ± 0.7	$18.6\pm0.9*$
Meary-Tomenon angle (°)	2.14 ± 4.8	$1.3 \pm 2.5*$

AOFAS, American Orthopedic Foot Andankle Society.

*p < 0.05 compared with pre-operation.

the inside of the left foot for over 2 years and was diagnosed with MWD at the IV stage. The AOFAS of this patient was 44, and the X-ray foot length and arch height were 15 cm and 10 cm, respectively, with the Meary-Tomenon angle of 3°. Fig. 1A and B show preoperative general photos of both feet. The patient received weightbearing X-rays of the left foot (lateral, posterior, positive, oblique, and the Sailzman position) (Fig. 1C-G), computed tomography (CT) (Fig. 1H, I) and MRI T1, T2 image recording (Fig. 1J, K).

The triple and talonavicular arthrodesis were conducted (Figs. 2, 3). Firstly, the talonavicular joint surface was exposed and the navicular bone was completely squeezed out to form a "talar wedge joint" (Fig. 2A). The excess osteophytes were exposed and cleaned up (Fig. 2B, C). Then, osteotomy (Fig. 2D) and the implantation of the autogenous iliac bone graft were conducted and made fixation (Fig. 2E, F). And the intraoperative X-rays of lateral view (Fig. 3A-C, E) and anteroposterior view (Fig. 3D, F) showed good consolidation of the triple arthrodesis.

The follow-up of the patient was performed after 1 month (Fig. 4A), 3 months (Fig. 4B), and 12 months (Fig. 4C) after the surgery, and the radiographs were taken dur-

ing the follow-up evaluation. It was presented that all the operated feet fused solidly, and none had any wound or neurovascular complications. The internal fixation device was removed from the suffered foot after 12 months of the operation and photographed by X-rays from the weightbearing lateral position (Fig. 5A), oblique position (Fig. 5B), and upright position (Fig. 5C), and the Sailzman position (Fig. 5D).

Discussion

Spontaneous osteonecrosis of the tarsal navicular bone in adults is termed Müller-Weiss syndrome, which is slightly different from the well-known Köhler disease in children (Tosun et al. 2011; Wang et al. 2012). Multiple factors could lead to chondrification, ossification, or osteocyte death in cartilage, such as damage to the blood supply of the tarsal navicular bone (DiGiovanni et al. 2007). The MWD patients always complained of long-standing mechanical pain in the midfoot induced by foot deformity. The severity of MWD patients can be estimated by a 5-stage system, which was developed by Maceira and Rocheira (2004) and has been widely accepted in the clinic. The pain of MWD patients is usually caused by the peri-



Fig. 1. Preoperative physical photographs and X-ray of the affected foot.
(A, B) Preoperative general photo of both feet. (C) The preoperative weight-bearing lateral position of the left foot. (D) The posterior position of the left foot before surgery. (E) Preoperative left foot positive position. (F) Preoperative left foot oblique position. (G) Preoperative left foot Sailzman position. (H) Preoperative CT plain scan. (I) Preoperative CT sagittal position. (J, K) Preoperative MRI T1, T2 images.



Fig. 2. Intraoperative photo.

(A) The articular surface of the talonavicular is exposed, and the navicular bone of the foot is completely squeezed out to form a "talar wedge joint". (B, C) The excess osteophytes are exposed and cleaned up. (D) Osteotomy. (E) Autologous iliac bone grafting. (F) Implantation and internal fixation.



Fig. 3. Intraoperative fluoroscopy. Intraoperative X-rays of the triple joint fusion about lateral view (A-C and E) and anteroposterior view (D, F).

navicular osteoarthritic changes, talonavicular arthrodesis, triple arthrodesis, and talonavicular-cuneiform arthrodesis (Monteagudo and Maceira 2019). Initial conservative treatments, such as the oral medication of anti-inflammation and the ankle-foot orthoses, were always conducted for early MWD patients (Mohiuddin et al. 2014). However, a number of patients at an advanced stage showed resistance to conservative treatments, which made surgical intervention necessary.

Previously, several studies have been devoted to improving the clinical therapy of MWD. For instance, Yuan et al. (2019) conducted the derotation of the talus and



Fig. 4. Review situations of patients after the operation after 1 month (A), 3 months (B), and 1 year (C).



Fig. 5. The internal fixation device was removed after the operation.(A) Left foot weight-bearing lateral position. (B) Left foot oblique. (C) Left foot in the front position. (D) Left foot in Sailzman position.

arthrodesis treatments on the stage II-V MWD patients, which significantly corrected the foot deformation and improve corresponding functions. A three- to eight-year follow-up survey demonstrated that the isolated talonavicular arthrodesis could achieve a satisfactory improvement in the outcome of MWD patients (Harnroongroj and Chuckpaiwong 2018). No matter what kind of surgical intervention is performed, the unifying principle for the MWD therapy is relieving pain, correcting deformation, restoring arch and medial column length, and fixing firmly (Doyle et al. 2012).

It is difficult for the traditional diagnostic methods to observe the minimal changes in the adjacent joints (Welck et al. 2016). MRI scans could offset the shortcoming of the traditional diagnosis, where the T1-weight images showed the reduced signal intensity of navicular and the T2-weight images showed the condition of periarticular fluid and edema (https://dtb.bmj.com/content/49/12/141.long) (Kottmeier et al. 2020). Herein, moderate MWD patients who were diagnosed with MRI scans and showed no improvement after conservative treatments were studied and received a triple and talonavicular arthrodesis. It was found that the conducted surgery implemented an approving enhancement in patients' outcomes and conditions. Specifically, the AOFAS, X-ray length, and arch height were elevated by the triple and talonavicular arthrodesis, which also reduced the Meary-Tomeno angle of patients. Meanwhile, the conducted surgical treatment in the present study also showed a satisfying union time (average union time of 13.6 weeks) without any complications, such as wound infection and skin necrosis, indicating the jake therapeutic effect of the triple and talonavicular arthrodesis on advanced-stage MWD patients. However, patients at different stages were enrolled in the present study, and it is necessary to evaluate the effect of the triple and talonavicular arthrodesis on patients with different stages to clarify its scope of application, which should be considered in the future investigations.

On the other hand, through typical case analysis, the specific procedure and therapeutic effect of the triple and talonavicular arthrodesis have been shown in detail. Hence, the present study not only provides a novel idea for the management of MWD but also gives the reference procedure for the clinical application of triple and talonavicular arthrodesis in the treatment of MWD.

However, it should be notable that there are also several disadvantages of the arthrodesis treatments, such as the prolonged recovery and the easy and high rate of complications (Toolan 2002). The pain of MWD patients is also caused by complicated factors not limited to the degeneration of joints. Therefore, except for the degenerative joints and collapsed medial arch, attention is also needed in the correction of hindfoot varus.

In conclusion, the triple and talonavicular arthrodesis could be applied in the clinical therapy of MWD patients at the III-V stage, which significantly ameliorated the outcome of patients and achieved satisfactory therapeutic effect.

Conflict of Interest

The authors declare no conflict of interest.

References

- Aebi, J., Horisberger, M. & Frigg, A. (2017) Radiographic study of pes planovarus. Foot Ankle Int., 38, 526-531.
- DiGiovanni, C.W., Patel, A., Calfee, R. & Nickisch, F. (2007) Osteonecrosis in the foot. J. Am. Acad. Orthop. Surg., 15, 208-217.

- Doyle, T., Napier, R.J. & Wong-Chung, J. (2012) Recognition and management of Muller-Weiss disease. *Foot Ankle Int.*, 33, 275-281.
- Fernández de Retana, P., Maceira, E., Fernández-Valencia, J.A. & Suso, S. (2004) Arthrodesis of the talonavicular-cuneiform joints in Müller-Weiss disease. *Foot Ankle Clin.*, 9, 65-72.
- Harnroongroj, T. & Chuckpaiwong, B. (2018) Muller-Weiss disease: three- to eight-year follow-up outcomes of isolated talonavicular arthrodesis. J. Foot Ankle Surg., 57, 1014-1019.
- Kitaoka, H., Alexander, I., Adelaar, R., Nunley, J., Myerson, M. & Sanders, M. (1994) Clinical rating systems for the anklehindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int.*, 15, 349-353.
- Kottmeier, L.K., Seehusen, F., Helweg, M., Rohn, K., Stadler, P. & Hellige, M. (2020) High-field (3 Tesla) MRI of the navicular apparatus of sound horses shows good agreement to histopathology. *Vet. Radiol. Ultrasound*, **61**, 48-57.
- Li, H.M. & Lui, T.H. (2020) Correction of severe flatfoot deformity by 3-portal arthroscopic triple arthrodesis. *Arthrosc. Tech.*, 9, e103-e109.
- Lopez, R., Singh, T., Banga, S. & Hasan, N. (2012) Subtalar joint arthrodesis. *Clin. Podiatr. Med. Surg.*, 29, 67-75.
- Maceira, E. & Rochera, R. (2004) Muller-Weiss disease: clinical and biomechanical features. *Foot Ankle Clin.*, 9, 105-125.
- Mohiuddin, T., Jennison, T. & Damany, D. (2014) Muller-Weiss disease - review of current knowledge. *Foot Ankle Surg.*, 20, 79-84.
- Monteagudo, M. & Maceira, E. (2019) Management of Müller-Weiss disease. Foot Ankle Clin., 24, 89-105.
- Perisano, C., Greco, T., Vitiello, R., Maccauro, G., Liuzza, F., Tamburelli, F.C. & Forconi, F. (2018) Mueller-Weiss disease: review of the literature. J. Biol. Regul. Homeost. Agents, 32, 157-162.
- Qu, F., Cai, J., Liang, X., Li, Y., Lu, J., Ji, W. & Zeng, Q. (2019) Short-term effectiveness of talonavicular joint arthrodesis and calcaneus osteotomy for Müller-Weiss disease. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi*, 33, 166-169.
- Toolan, B.C. (2002) Midfoot arthrodesis: challenges and treatment alternatives. *Foot Ankle Clin.*, 7, 75-93.
- Tosun, B., Al, F. & Tosun, A. (2011) Spontaneous osteonecrosis of the tarsal navicular in an adult: Mueller-Weiss syndrome. J. Foot Ankle Surg., 50, 221-224.
- Wang, X., Ma, X., Zhang, C., Huang, J.Z. & Jiang, J.Y. (2012) Flatfoot in Muller-Weiss syndrome: a case series. J. Med. Case Rep., 6, 228.
- Welck, M.J., Kaplan, J. & Myerson, M.S. (2016) Muller-Weiss syndrome: radiological features and the role of weightbearing computed tomography scan. *Foot Ankle Spec.*, 9, 245-251.
- Wong-Chung, J., McKenna, R., Tucker, A., Gibson, D. & Datta, P. (2021) Radiographic analysis of Muller-Weiss disease. *Foot Ankle Surg.*, 27, 501-509.
- Yu, G.R., Zhao, Y.G., Zhou, J.Q., Li, H.F., Yang, Y.F. & Li, B. (2012) Surgical treatment for Müller-Weiss disease. *Zhon-ghua Wai Ke Za Zhi*, **50**, 894-897.
- Yuan, C., Wang, C., Zhang, C., Huang, J., Wang, X. & Ma, X. (2019) Derotation of the talus and arthrodesis treatment of stages II-V Muller-Weiss disease: midterm results of 36 cases. *Foot Ankle Int.*, 40, 506-514.