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**In Patients with End-Stage Ankle Arthritis, How Does Total Ankle Arthroplasty
Compared to Arthrodesis Affect Ankle Pain and Function?**

By

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Introduction

End-stage ankle arthritis is a debilitating degenerative disease commonly located at the tibiotalar joint. The prevalence of symptomatic arthritis is about nine times lower than the rates associated with those of the knee or hip.¹ Though less common than knee and hip arthritis, the US estimates greater than 50,000 new cases are reported each year.² The most common etiology of ankle arthritis is post-traumatic pathology. Other etiologies related to ankle degeneration include primary degenerative disease, rheumatoid disease, osteonecrosis, neuropathologies, infection, and gout.³ Injury to the joint damages the intraarticular cartilage leading to changes in joint mechanics. These alterations cause the joint to wear out more rapidly, leading to complete obliteration of the joint space, significant pain, and functional impairment. Many treatment options are available for end-stage ankle arthritis; however, total ankle arthroplasty (TAA) and arthrodesis are considered standards of care.⁴

Background

Ankle arthrodesis was introduced initially in the 1870s as external fixation of the joint. Shortly thereafter, internal fixation was shown to be an effective treatment option. In the 1980s, arthroscopy became a third ankle fusion technique. Currently, arthroscopic fusion, external fixation with tension wiring, and open internal fixation with plates or screws are utilized procedures for treating end-stage ankle arthritis.⁵

Total ankle arthroplasty (TAA) was first introduced in the 1970s. Nevertheless, arthrodesis was still the preferred treatment choice and was used more frequently than TAA. The reason that TAA was not adopted initially can be explained by the relatively high failure and revision rates.³

These poor outcomes were due to poor implant design, excessive bone resection, inappropriate indications, and inadequate cement technique.² Patients who experienced implant failure required multiple revision procedures or salvage arthrodesis. Patients who underwent salvage arthrodesis experienced reduced function and debilitating pain.⁶ Salvaging a failed ankle replacement is an arduous and complex process that may involve multiple procedures, and lead to more frequent complications. Prior to newer generation implants, these undesirable outcomes persuaded patients to choose the more predictable arthrodesis. Albeit arthrodesis was the preferred treatment in the past, in the last decade TAAs increased 1000%.⁵ This shift is largely due to advancements in implant design and durability. These new designs included uncemented, fixed bearing, and mobile bearing implants.

With advancements in implant design, TAA established its superiority to arthrodesis; nonetheless, the debate continues about which procedure should be the gold standard.³ Although a substantial amount of research is available on the treatment of end-stage ankle arthritis, uncertainty remains about the effects of arthroplasty on pain and function compared to the effects resulting from arthrodesis. Before comparing the benefits of these surgeries, familiarity with the methods of assessing these outcomes is necessary.

Methods of Assessing Pain and Function

Commonly used tools for assessing pain and function in orthopedics include the Musculoskeletal Function Assessment (MFA) questionnaire, the Medical Outcomes Short-Form 36 (SF-36) questionnaire, American Orthopedic Foot and Ankle Society Score (AOFAS), range of motion (ROM) analysis, and full-body gait analyzing technology.

The MFA evaluates a patient's perception of psychological, social, and physical well-being. This self-reporting questionnaire includes 100 items in order to evaluate function. Higher scores indicate reduced function. The MFA is a validated study that has been shown to have minimal ceiling effects and excellent sensitivity to change.⁵ The SF-36 is a 36-item survey that investigates eight different areas including; physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health. Role physical and role emotional includes difficulties with work or daily activities due to physical health problems and emotional health problems respectively. Higher scores indicate higher function.⁵ The AOFAS is a clinician reporting tool that incorporates evaluations by both the patient and the provider. This survey includes subjective and objective questions designed to investigate pain, function, and anatomical alignment. Four AOFAS surveys are independently used based on anatomical regions of the foot. Though the AOFAS has yet to be validated, physicians continue to administer it to patients concurrently with other more robust assessment tools.¹

Discussion

Recent research includes direct comparisons between arthrodesis and TAA. In a 2017 prospective cohort study, Sangeorzan et al. compared arthrodesis with two generations of TAAs. The MFA and SF-36 questionnaires were used to assess outcomes in the 273 patients who were followed for three years. There were strict surgeon requirements and surgical protocols in place in order to limit confounding variables. Since the study included a non-random sample, patient demographics were analyzed attempting to eliminate any possible bias. At three years, average MFA and SF-36 scores improved significantly in the arthroplasty groups compared with the arthrodesis recipients.⁵ Superior outcomes were even more prevalent in patients who received the newer generation implant. Both arthroplasty and arthrodesis patients who were younger had

greater MFA score improvements than older patients, and patients with lower BMIs had better physical function outcomes. Age, BMI, deformity, and other comorbid conditions are essential factors to consider when determining a suitable treatment plan.⁵

In an earlier study from 2009, Saltzman et al. found similar success with TAA. The safety and efficacy of the Scandinavian Total Ankle Replacement (STAR) compared with ankle fusion were examined in this multi-center prospective, non-random Investigational Device Exemption (IDE) study for the FDA. There were two phases in the study. The first phase (Pivotal Study), included patients treated with either the STAR group (1yr & 3 months enrollment period) or a concurrent ankle fusion control group (4yr & 7 months enrollment period) included 158 STAR patients and 66 arthrodesis patients. The second phase continued access study consisting of 448 patients treated with STAR implants at the same institutions where the pivotal study was conducted. The sample size and study design are two major strengths that significantly increase the studies power and quality of evidence. Both the pivotal study and controlled access group had follow-ups at 24 months, and assessment tools included Buechel-Pappas (BP) pain score, the Visual Analog Scale, a patient satisfaction survey, and SF-36 form. In addition, radiographs were obtained to evaluate fusion success, and to screen for subsidence and migration of the prosthesis.²

Before interpreting the findings, there are several limitations that need to be considered. The non-random design is that the arthroplasty and arthrodesis patients were enrolled at different medical centers. Being from different centers lead to the groups being fairly different. Arthroplasty patients were, on average, significantly older, had worsened preoperative function,

a higher preoperative pain, and a greater incidence of rheumatoid arthritis. These factors may have biased the study in favor of the fusion group.²

After 24 months, patients in the STAR arthroplasty group had a 50% improvement in their BP total pain scores compared with the arthrodesis group.² Specifically, patients reported significant improvement in function and ROM. Both groups experienced pain reduction compared with their pre-operative state. Thus, the STAR implant was found to be safe and effective.² Patients in the controlled access group also had similar results at 24 months. Data collection for the continued access group is ongoing in order to determine durability and the long-term effects on gait.²

Additionally, Segal et al. conducted a three-year prospective non-randomized cohort study in 2018, which compared biomechanics in patients who received TAA to arthrodesis. The study population included patients 18 years and older with end-stage arthritis who have failed conservative treatment. Patients were excluded if they had received any recent (< 1 year) surgical lower-extremity interventions that caused patients to present with neurological, metabolic or orthopedic impairment. Following appropriate screening 27 patients were scheduled for arthroplasty and 20 were scheduled for arthrodesis. However, due to poor follow-up, only 13 arthroplasty patients were incorporated into the final analysis. Having a small sample size is a factor that could increase variability and affect the ability to detect small differences. Though having a small sample raises concern, comparison of the unaffected limb and the prospective study design increase the power of the study.⁷

Lower extremity kinematics (sagittal ankle, knee, and hip ROM) were analyzed with Vicon's Plug-In Gait (Vicon, Centennial, CO, USA) system using body markers and 12-camera

system. Patients also completed MFA and SF-36 questionnaires. Postoperatively, both arthroplasty and arthrodesis groups had similar MFA and SF-36 scores, suggesting that patients experience improved function and reduced pain initially. Segal et al. also found that both arthroplasty and arthrodesis patients experienced a significant increase in walking speed however, increased speed was achieved differently in each surgical group. Arthrodesis patients increased had a significant increase in step length ($+\Delta 0.08\text{m}$ [0.02, 0.13], $P=0.002$), whereas arthroplasty patients increased cadence ($+\Delta 7$ steps/min [0, 13], $P=0.033$) and reduced step duration ($-\Delta 0.04$ s [-0.07, 0.00], $P=0.021$). Those who had an increase in step length were also found to have increased hip ROM, suggesting compensation for reduced ankle ROM.⁷

Summary of Current Research

Over the last decade, TAA resurfaced as a practical and frequently preferred treatment option for end-stage ankle arthritis. In summary, recent research revealed TAA to be superior to arthrodesis in both short- and intermediate- terms for improving pain and function.^{2,5}

Though evidence has shown arthrodesis union rates ranging between 75% and 93%; patients continued to report significant long-term reductions in pain when their post-operative scores.⁸ Arthrodesis is also a more predictable and definitive treatment option if union is successful. If arthrodesis fails, non-unions can result in debilitating pain and will likely require revisional surgery. Many risk factors for fusion failure have been reported, with infection and avascular necrosis having the highest non-union rates. These are closely followed by followed by talar dome fractures, tibial plafond fractures, and open fractures.³ Compared to primary arthrodesis, surgical treatment of a non-union/malunion is not only difficult but also associated with higher complication rates and worse clinical outcomes.⁴

Even with a successful fusion, patients are still at risk for future complications and functional limitations. Arthrodesis has been shown to improve gait and walking speed relative to the pre-operative state, but fusion results in amplified stress on adjacent or proximal joints.⁷ Since fusion decreases tibiotalar motion, compensation at the talonavicular, knee, and hip joints is inevitable.^{3,7} Some studies with intermediate- and long-term follow-up have shown that arthrodesis is a risk factor for accelerating joint degeneration the hindfoot and midfoot. Moreover, Lawton et al. found that both TAA and arthrodesis patients are susceptible to developing adjacent joint arthritis.⁹ To date evidence of negative impacts on the knee and hip joints due to these procedures is lacking.³

Despite the benefits of arthrodesis, TAA has become an alternate procedure of choice for end-stage ankle arthritis because of recent improvements in design and techniques. The latest generation implants have 5-year survival rates of up to 90% and 10-year rates of 80%.⁸ Arthroplasty has also been shown to be effective in preserving the ankle joint dynamics, thus maintaining a more natural gait, which reduces other joint compensation, and minimizes load through adjacent joints.² Additionally, Pedowitz et al. found that arthroplasty patients had a significantly higher arc of motion at the talonavicular joint and an overall increased ROM compared to the arthrodesis group. Besides increased function, pain and patient-perceived outcomes improved significantly.¹⁰

Conclusion

End-stage ankle arthritis is a debilitating disease that significantly reduces the patient's quality of life. Both arthroplasty and arthrodesis have been shown to be viable treatment options for end-stage ankle arthritis. Current evidence reveals that TAA is superior to arthrodesis for

improving pain and function. Though these recent studies have illuminated the role of TAA for end-stage ankle arthritis, evidence for durability of benefits is lacking. Research utilizing larger populations and longer follow-up are needed to assess the generalizability and durability, respectively, of this procedure. Until more definitive evidence distinguishes the benefits and risks of these alternative treatments, it's vital that providers understand how to counsel patients and are able to determine appropriate treatment options case by case.

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