A growing number of patients are seeking alternative treatment options for ankle arthritis other than arthrodesis or total joint replacement. Many patients prefer to preserve their natural ankle joint and ankle movement. Although research into cartilage regeneration and repair is promising, it is preliminary; nevertheless, at the current time, ankle distraction offers viable clinical outcomes.

Indications for ankle joint distraction are congruent joint surface, pain, joint mobility, and moderate to severe arthritis. The indications may be stretched to include avascular necrosis of the talus. Good clinical outcomes of ankle joint distraction with external fixation have been reported to range from 70% to 78% (studies by Paley and colleagues in 2008 and by van Roermund and colleagues). The rationale as to why joint distraction is successful is largely unknown. Therefore, the purpose of this study was to evaluate pre- and postoperative ankle MRI scans of patients who underwent hinged ankle joint distraction with external fixation so as to understand better the effects of distraction on the joint.
EXISTING METHOD AND RESULTS

van Roermund and his coworkers\textsuperscript{5–12} have written at length about the treatment of arthritis of the ankle with joint distraction. Ankle distraction treatment removes the mechanical stress (weight-bearing forces) on the cartilage to allow for restoration. Weight bearing with the external fixator allows for continued intermittent intra-articular fluid pressure and increased synovial fluid, which further aids in cartilage restoration. Maintaining the fixator for 3 months allows for reduction in the subchondral bone density, which increases the resilience of the joint. These effects of joint distraction allow for cartilage repair (ie, fibrocartilage).

The protocol that the Dutch group uses involves application of the Ilizarov device (a two-ring construct) to the tibia with two 1.5-mm Kirschner wires per ring attached by means of four threaded rods to a U-shaped foot ring (closed distally). A talar wire to prevent distraction of the subtalar joint, two crossing calcaneal olive wires, and one medial olive wire through the metatarsals are fixed to the foot ring. Distraction is performed at a rate of 0.5 mm two times per day for 5 days to achieve a total distraction of 5 mm. This distraction is maintained for 3 months, during which full weight bearing is allowed. The device is not hinged.

van Roermund and his coworkers\textsuperscript{5–12} report that 70% of their patients showed significant clinical improvement, including a decrease in pain and increase in function (results for 50 patients with 2–8 years of follow-up). Joint mobility was sustained with the distraction treatment but was markedly restricted (50% of normal range). Most notable was the timing of the clinical improvement, with only one half of the clinical improvement occurring within the first year after the procedure. A slight increase in joint mobility, significant widening of the joint space, and diminished subchondral sclerosis were progressively observed during the 5 years after the procedure. These researchers also performed a prospective controlled study showing that joint distraction led to a statistically significant better clinical outcome than did arthroscopic débridement of the ankle joint alone.\textsuperscript{5,8,9} In summary, van Roermund and his colleagues\textsuperscript{5,6} showed that static ankle distraction alone without range-of-motion exercises yields a positive clinical effect in 70% of cases.

BALTIMORE TECHNIQUE

\textit{Hinged Ankle Joint Distraction}

Unlike the Dutch group, the authors prefer to build their ankle distractor with an anatomically located hinge, which allows the patient to perform range-of-motion exercises throughout the entire distraction treatment. Inman’s axis of the ankle joint is located during surgery, and universal hinges are placed medial and lateral to allow for hinged motion about this axis during treatment.\textsuperscript{13} In addition, the authors combine concomitant correction of osseous alignment, muscle and joint contractures, and joint impingement to improve results.

ADJUNCTIVE PROCEDURES

\textit{Blocking Osteophyte Resection}

If dorsiflexion is limited by anterior distal tibial or talar neck osteophytes, the osteophytes should be resected. An anterior approach is used to resect the anterior distal tibia and to deepen the neck of the talus. If plantarflexion is limited by posterior ankle osteophytes, they should be resected through a posterolateral incision (ie, Gallie approach) to gain access to the posterior ankle capsule. To prevent recurrence of these osteophytes, bone wax may be pressed into the cancellous bone. The authors also use nonsteroidal anti-inflammatory drugs (NSAIDs) (eg, indomethacin, naproxen)
after surgery to inhibit bone formation for 6 weeks. However, NSAIDs are not used if an osteotomy is performed concomitantly.\textsuperscript{14}

\textit{Equinus Contracture Release}

Isolated anterior or posterior gastrocnemius recession (Baumann or Strayer procedure, respectively), gastrocnemius-soleus recession (modified Vulpius procedure), or Achilles tendon lengthening can be performed to correct equinus contracture.\textsuperscript{15–17} The authors prefer the isolated gastrocnemius recession or gastrocnemius-soleus recession to maintain triceps surae muscle strength. A posterior capsular release may also be required to restore the ankle joint motion if the aforementioned procedures are not enough to correct the equinus. Tarsal tunnel decompression should be considered in acute and gradual correction of equinus contractures.\textsuperscript{18} The tarsal tunnel decompression and the posterior ankle capsular release can be accomplished through a posteromedial longitudinal incision. The posterior osteophytes can also be resected through a posteromedial incision. When acute release is not sufficient to reduce the equinus, the residual equinus can be corrected using gradual distraction.

\textit{Ankle Joint Realignment}

Ankle joint malalignment attributable to deformities (eg, valgus/varus, recurvatum/procurvatum, internal/external rotation) may be the cause of ankle joint degeneration.\textsuperscript{16} To increase the longevity of the ankle joint cartilage, reorientation procedures, such as supramalleolar osteotomy, realign the ankle joint plafond. Subtalar contractures can be acutely reduced through a release or gradually corrected with the use of an external fixator. It is important to assess compensatory deformities accurately before surgical intervention.\textsuperscript{16,19} Correction of ankle alignment is usually done using a supramalleolar osteotomy. This can be carried out acutely and fixed internally while the distraction is performed with external fixation. An alternative is to perform acute or gradual distal tibial realignment and ankle distraction with the same external fixator.

Distraction of 2 mm is performed in the operating room to ensure symmetric ankle joint distraction. Then distraction starts at a rate of 1 mm per day on postoperative day 1 for a total of 5 days. The goal is to achieve 8 to 10 mm of symmetric ankle joint distraction. The external fixation device is maintained for 3 months while allowing weight bearing as tolerated. The patient removes the posterior distraction rod to perform daily ankle range-of-motion exercises and attends physical therapy three times a week during the distraction treatment.

\textbf{MATERIALS AND METHODS}

The authors retrospectively reviewed the charts of three patients (three ankles) who underwent hinged ankle distraction with external fixation and had a minimum of 1-year of follow-up. All patients were diagnosed with painful ankle arthrosis based on clinical and radiographic evidence, and all patients were offered ankle fusion as an alternative treatment. The senior author (BML) performed the operation on the aforementioned patients between 2005 and 2007. The following information was obtained from the patients’ records: gender, age, follow-up time, method of distraction, length of distraction, and preoperative diagnosis.

Pre- and postoperative T1- and T2-weighted sagittal and coronal MRI scans were collected from all three patients. The average duration between the time of surgery and the follow-up MRI was calculated. On the pre- and postoperative MRI scans, the subchondral bone thickness on the tibia and talus, the cartilage thickness or joint
RETROSPECTIVE REVIEW RESULTS

Three patients’ (two men and one woman) pre- and postoperative MRI scans were available for review. The average age of the patients was 41 years. Two right ankles and one left ankle underwent hinged ankle joint distraction. The preoperative diagnoses were posttraumatic ankle arthritis in all three patients. The average duration of treatment with external fixation was 4 months, followed by 1 month in a walking cast.

The pre- and postoperative T1- and T2-weighted sagittal and coronal MRI scans were compared. The postoperative MRI scan was obtained an average of 13 months after the initial distraction surgery. The MRI comparisons showed that the average postoperative subchondral bone thickness decreased by 0.5 mm, the average postoperative cartilage thickness or joint space increased by an average of 0.5 mm, and the average subchondral bone cysts of the talus and tibia decreased in number and size.

As a case example, a 44-year-old man with posttraumatic ankle arthritis underwent removal of the anterior ankle osteophytes and hinged ankle joint distraction with an external fixator (Figs. 1–4). The fixator was sustained for 4 months and then removed. MRI scans were obtained before surgery and 12 months after surgery. Note that the MRI scan was taken 8 months after removal of external fixator.

DISCUSSION

The reason why ankle distraction leads to lasting pain relief when treating ankle joint osteoarthritis is still speculative. It is possible that distraction permits cartilage repair to occur in a protected low-pressure environment. Salter and colleagues\(^{20}\) showed that cartilage repair (fibrocartilage) occurs within a cartilage defect. Similarly, fibrocartilage formation was seen on the postoperative MRI scans in the current study.

![Fig. 1. Preoperative and postoperative T1-weighted coronal MRI scans. The ankle joint space or cartilage thickness is wider after surgery.](image-url)
Fibrocartilage formation is the body’s attempt to restore a normal joint surface. Pain from osteoarthritis may be related to the effect of hydrostatic pressure on a subchondral bone cyst, whereby the synovial fluid from the joint enters through a cartilage defect (cavity) and increases the fluid, and thus the pressure, within the subchondral bone cyst. Joint distraction allows for the formation of fibrocartilage, which adequately seals the cartilaginous cavity to the subchondral bone cyst, and therefore eliminates the increased fluid (pressure) and the pain.

Radiographs obtained after the external fixation is removed show that the joint distraction space of the ankle is not maintained. Typically, the radiographic joint space looks unchanged approximately 1 to 2 months after removal of external fixation.

Fig. 3. Preoperative and postoperative T1-weighted sagittal MRI scans. The ankle joint space or cartilage thickness is wider after surgery. The subchondral bone thickness after surgery may have slightly decreased.
Cartilage repair (ie, fibrocartilage) occurs during treatment, and the increased joint space or fibrocartilage after external fixation removal can be measured on the MRI scans. The findings of the MRI study show an increase of 0.5 mm of fibrocartilage, which has not been previously reported.

The authors’ results showed decreased thickness of the subchondral bone after surgery. This finding has also been reported by the Dutch group in previous radiographic studies. This response to the 4 months of ankle distraction is beneficial because it increases the resiliency of the cartilage overlying the subchondral bone.

**SUMMARY**

Ankle joint distraction is a viable alternative to ankle arthrodesis or ankle replacement. The main goal of ankle joint distraction is to decrease or eliminate pain and to delay the need for joint fusion or replacement. The authors’ approach of osteophyte resection, muscle and joint contracture release, and osseous ankle realignment procedures, along with hinged ankle joint distraction, has proved to be clinically successful. The reason(s) why joint distraction is successful is largely unknown. This preliminary pre- and postoperative MRI comparison study showed that fibrocartilage forms during the 4 months of joint distraction, increasing joint space (0.5 mm), which has not been reported in previous radiographic studies. Theoretically, the formation of fibrocartilage merely seals the cartilage cracks and eliminates the synovial filling of the subchondral bone cyst, thereby decreasing the joint pain.

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Fig. 4. Preoperative and postoperative T2-weighted sagittal MRI scans. The subchondral bone cysts of the tibia and talus have become diffuse after surgery. The tibia and talus have increased signal, but no subchondral bone cysts are seen. Note the resection of the anterior tibial osteophytes and the deepening of the talar neck.