Microtenotomy Using a Radiofrequency Probe to Treat Lateral Epicondylitis

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Purpose: To evaluate the safety and effectiveness of microtenotomy using a radiofrequency (RF) probe to treat chronic tendinosis of the common extensor tendon origins of the elbow (lateral epicondyle). **Type of Study:** Prospective, nonrandomized consecutive case series. **Methods:** The average age of the 13 patients was 48.3 ± 5.5 years. Before receiving the microtenotomy, all patients had tendinosis symptoms for 6 months or longer and had failed conservative treatment. The RF-based microdebridement was performed on the symptomatic tendon using the TOPAZ Microdebrider device (ArthroCare, Sunnyvale, CA). Patients were followed-up at regular postoperative intervals for 24 months. Pain status was documented using a visual analog scale self-reported measure. Functional outcome was assessed using the upper limb DASH evaluation and grip-strength measures. Quality of life assessment was evaluated using the SF-36 questionnaire. Magnetic resonance imaging was performed at regular intervals over the follow-up period. **Results:** Patients reported significantly reduced pain from baseline at the 7- to 10-day postoperative examination ($P \leq .01$). Pain reduction was statistically stable from 7 to 10 days through the 24-month postoperative period ($P \leq .01$). Limb-specific functional outcomes and quality of life scores were improved over baseline values. There were no perioperative or postoperative complications related to the procedure. **Conclusions:** The RF-based microtenotomy procedure was safe and effective through at least 2 years. This procedure provides a valuable addition for treating patients with lateral epicondylitis associated with tendinosis who have failed conservative therapy. **Level of Evidence:** Level IV. **Key Words:** Tendinosis—Tennis elbow—Radiofrequency—Ablation—Epicondylitis—Electrosurgery—Plasma-mediated—Microtenotomy.

Tendinosis is a common orthopaedic condition that is often refractory to nonsurgical therapies. Basic science research and clinical study has suggested that it is a noninflammatory, degenerative condition,[1-4] clinically associated with overuse.[4-9] Tendinosis is characterized by an absence of inflammatory cells, an abundance of disorganized collagen and fibroblastic hypertrophy, and disorganized vascular hyperplasia with avascular tendon fascicles. Vascular structures are believed to be nonfunctional.[5] Other studies have also suggested that nutritional flow through the affected tendon is compromised, making it difficult for tenocytes to synthesize the extracellular matrix necessary for repair and remodeling.[10,11] A principal aim in treatment of tendinosis is to establish a biologic healing response.[4]

Transmyocardial revascularization (TMR) has been used successfully as a technique to improve function of the ischemic heart. Initially introduced in the 1960s as transmyocardial acupuncture, the objective was to convey blood directly from the ventricular cavity into myocardial tissue or coronary vessels.[12-14] The acupuncture method did not prove to be as clinically successful as anticipated in the longer term.[15] With

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widespread acceptance of laser technology, TMR was revived with excellent clinical success during the mid 1990s; it was considered to provide a better means for establishing channel patency than mechanical methods. Initially, practitioners promoted the perfusion approach proposed by Sen and other early investigators[12-14]; however, later studies suggested that the benefits of laser TMR were likely a result of localized angiogenesis.[15]

Laser- or RF-based TMR is superior to mechanical means for achieving a beneficial clinical response.[16-19] The angiogenic response observed with laser- and RF-based TMR has been shown by studies evaluating changes in histology as well as biochemical markers, such as fibroblastic growth factor (FGF) and vascular endothelial growth factor (VEGF).[19-23] Simultaneous study of changes in clinical behavior, shown by decreased incidence of angina and increased tolerance to exercise, and changes in histology findings, indicating that vascularity was increased by 50% and proliferation of vascular cells was tripled, confirmed that improved function occurs in conjunction with an angiogenic physiologic response after RF-based TMR.[23] Postmortem evaluations noted evidence of new capillary development even after ablated channels had knitted.[24,25]

This body of research led us to evaluate whether a procedure such as TMR using an RF-based approach might be valuable for treating tendinosis. In an initial small clinical study in patients with chronic tendon injury in the rotator cuff, we detected physiologic evidence of an impaired healing response; specifically, reduced levels of angiogenic growth factors compared with noninjured patients.[26] A subsequent preclinical study showed that RF-based microtenotomy was effective for stimulating an angiogenic healing response in tendon tissue.[27] Histologic evaluation of treated tendons showed an early inflammatory response, with new blood vessel formation by 28 days. These findings were supported by histochemical analyses: VEGF and α_v integrin were significantly elevated compared with controls at 9 days and had returned to normal levels by 90 days.

Thus the purpose of this study was to evaluate the safety and effectiveness of using RF-based microtenotomy to treat tendinosis. To our knowledge, this is a novel approach for treating this condition. We hypothesized that this technique would induce a healing response, manifested clinically as reduced pain and improved function. The device used in this study was cleared by the United States Food and Drug Administration (FDA) for use in debridement of soft tissue, such as tendons.

METHODS

Patients

This was a prospective, nonrandomized, single-center clinical study. After receiving proper institutional review board approval, patients who were 18 to 65 years of age with a positive diagnosis of tendinosis were approached for enrollment into the study. Patients had to be symptomatic for at least 6 months and had to have undergone and failed extensive conservative treatments. Candidates with diabetes, confirmed or suspected pregnancy, prior surgery in the same tendon, osteosynthesis material observed adjacent to the target treatment region, or who were receiving care under Workers' Compensation, had litigation-related injury, or were participating in another related study were excluded.

Twenty consecutive patients with tendinosis of the elbow, knee, or Achilles tendon were enrolled. Results for the subset of 13 patients with tendinosis of the lateral epicondyle of the elbow are presented herein. One patient was a professional athlete (tennis) and 4 patients were serious recreational athletes; the remaining 8 had tendinosis resulting from repetitive leisure- or work-related activity.

A single clinician performed a thorough medical history and clinical evaluation. The clinical follow-up and data collection were performed by an independent medical technician. Baseline radiographs and magnetic resonance imaging (MRI) scans were obtained and examined to evaluate the tendinosis affected area and to rule out any other associated pathologic condition.

Clinical Outcomes

Patients were followed-up for 24 months after the procedure. Pain status was assessed by asking the patient to report pain using a visual analog scale (VAS) and collecting information on pain medication use. Limb function was evaluated using grip strength testing and the upper limb Disability of Arm, Shoulder, and Hand (DASH) outcome measure. Quality of life was assessed using the SF-36 questionnaire. Postoperative clinical assessment was conducted within the first 2 days; at 7 to 10 days; 4 to 6 weeks; and 3, 6, 12, and 24 months. MRI scans were obtained at baseline, at 6 weeks, and 6 and 12 months following the procedure.

The VAS scale was a horizontal 10-cm line with word anchors at each extreme, including no pain on one end (0) and worst pain imaginable at the opposite end (10). The patient was asked to mark a point on the line to represent the intensity of pain being experienced at the time of assessment. The patient's score was obtained by measuring, in centimeters, from the left side of the line (no pain or 0) the point the patient marked.

The DASH outcome measure is designed to evaluate 2 principal components: function and performance of the upper limb. The maximum possible raw score is 150 and the minimum is 30. To capture a DASH score, the raw score is transformed to coincide with a standardized scale ranging from 0, reflecting no disability, to 100, representing maximum disability.

Grip strength was collected for both treatment and nontreatment limbs. Patients were asked to perform 2 trials with each limb at each data-collection sitting. The Jamar Hydraulic Hand Dynamometer (Sammons Preston Rolyan, Bolingbrook, IL) was used to measure pound-force. The device was set at the third station for every trial. The average of both trials was used for data analysis.

The MRI scans were reviewed and compared twice by 2 independent MRI radiologists. These scans were obtained to study the possible preoperative and postoperative surgical changes as they related to clinical outcome as well as to screen for potential adverse effects.

The RF-Based Microtenotomy Device

The TOPAZ Microdebrider device (ArthroCare, Sunnyvale, CA), connected to a System 2000 generator set at setting 4 (175 V-RMS), was used to perform the RF-based microtenotomy. The device functions using a controlled plasma-mediated RF-based process (Coblation). In this process, RF energy is used to excite the electrolytes in a conductive medium, such as saline solution, to create a precisely focused plasma. The energized particles in the plasma have sufficient energy to break molecular bonds,[28,29] excising or dissolving (i.e., ablating) soft tissue at relatively low temperatures (typically 40°C to 70°C).[30,31] The diameter of the active tip of the TOPAZ device is 0.8 mm.

Surgical Procedure

The same surgeon (J.P.T.) performed the procedure in all cases. The symptomatic area of the tendon was identified and marked while patients were alert. After the patients were positioned appropriately, they were lightly sedated. A tourniquet was placed over the treatment limb and inflated to the appropriate pressure. A small incision, approximately 3 cm in length, was made over the marked treatment site to expose the involved tendon (Fig 1). After initiating sterile isotonic saline flow of 1 drop every 1 to 2 seconds from a line connected to the RF system, the tip of the device was placed on the tendon perpendicular to its surface. Using a light touch, it was activated for 500 milliseconds using a timer accessory for the control box. While developing the timer, it was established that it was necessary to apply only a light, guiding application, found to correspond to approximately 5 to 8 g of pressure, to penetrate the tendon as well as to achieve successful ablation. RF applications were performed at 5-mm distance intervals, to create a grid-like pattern on and throughout the symptomatic tendon area. The fascia or tendon was perforated to a depth of several millimeters on each second or third application. After treatment of the symptomatic area, the wound was irrigated with copious amounts of normal saline solution and closed with interrupted Nylon suture. Local anesthetic was injected in the skin and subcutaneous tissue only. Standard wound dressings were applied.

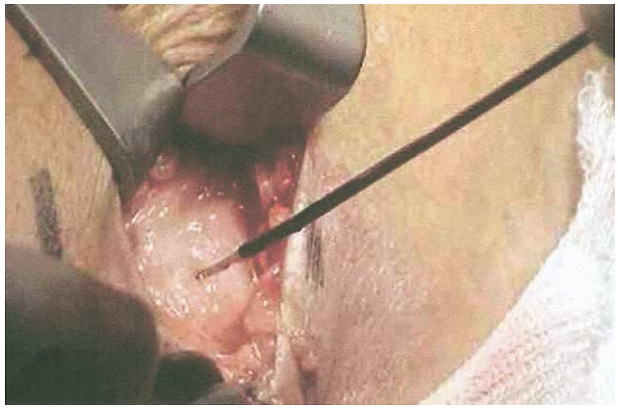

FIGURE 1. The exposed tendon under microtenotomy debridement using the TOPAZ device.

Statistical Analysis

Normally distributed data were described using standard parametric statistics (i.e., mean and standard deviation); nonnormally distributed data were characterized using nonparametric descriptors (median and quartiles). Statistical evaluation of improvement in pain status and DASH scores was performed by cal-

Table 1. *Patient Demographics*

Age (yr)	
Mean ± SD	48.6 ± 5.8
Median	50
Range	38-59
Gender	
Male	6 (46%)
Time spent with injury (yr)*	
Mean ± SD	4.4 ± 5.9
Median	1.5
Range	0.5-20
No. of treatments before microtenotomy	
Mean ± SD	4.5 ± 1.5
Median	4
Range	2-7
Medication Use	
None	9 (69%)
3-4 times a day	0
1-2 times a day	2 (13%)
Several times/week	2 (13%)
Once a week or less	0

*Data not available for 1 patient; recorded as "few years."

culating 99% confidence intervals and using the Student *t* distribution for change between subsequent time points. Use of confidence intervals provides a descriptive analysis of the observed treatment effect, while permitting determination of statistical relevance. In all statistical testing, confidence bounds not including zero were considered statistically significant. For grip strength, evaluation of improvement was performed by calculating the difference in grip strength scores between treated and untreated limb at baseline, 4 to 6 weeks, and 6 months. Score differences at 4 to 6 weeks were statistically evaluated against those at baseline using a dependent *t* test; the 4- to 6-week score differences were also compared with the score differences at 6 months. Probability of $P \leq .01$ for committing type I experiment-wise error (rejecting a true null hypothesis) was selected for all statistical testing because of our lack of a control group, small sample size, and evaluation of multiple postoperative time points.

RESULTS

Patients ranged in age from 38 to 59 years (Table 1). Duration of symptoms before receiving the RF-based microtenotomy ranged from 6 months to 20 years (4.2 ± 5.5 years) and patients had failed an average of 4.5 ± 1.5 conservative treatments. Through the 24-month follow-up period, 12 of 13 patients were successfully followed-up through 24 months and beyond.

Postoperative Clinical Sequelae and Significant Events

Ten of 13 patients (77%) experienced noticeable reduction of pain on the first or second postoperative day, and were able to separate the symptoms of tendinosis from the surgical wound pain. Symptoms related to the surgical incision included tenderness or slight swelling, slight stiffness, slight occasional pain, or mild discomfort and slight bruising. No perioperative or postoperative complications or adverse events were observed through the 24-month postoperative course. One patient reported increased pain at 4 to 6 weeks (VAS = 7), which she attributed to overexertion; she had recovered by the next follow-up examination.

Pain Assessment

Baseline VAS scores ranged from 5 to 10, with a median of 8. At all postoperative follow-up time points after 7 to 10 days, median scores were 2 or less (Table 2). The proportion of patients who reported minimal to no pain (VAS ≤ 1) at each postoperative visit increased steadily through the first 6 months. Pain was reduced significantly (5 to 6 points on a scale of 10) 7 to 10 days after the procedure ($P \leq .01$). Postoperative scores for pain were statistically stable ($P \leq .01$) over the follow-up period.

Functional Assessment

Grip strength in treated limbs at baseline was less than that in untreated limbs (Table 3). At the 4- to 6-week examination, grip strength in the treated limb was improved significantly ($P \leq .01$). Treatment-limb grip strength did not change significantly between 4 to 6 weeks and 6 months ($P \leq .01$). The median DASH score at baseline was 35, with a range of 20 to 59 (Table 4). The 4- to 6-week postoperative DASH score was significantly improved over baseline ($P \leq .01$); later postoperative scores were statistically stable or improved further ($P \leq .01$) through 1 year.

Quality of Life Assessment

Average quality of life scores for the study sample at postoperative months 6, 12, and 24 closely approximated values obtained for the U.S. reference sample aged 45 to 54 years old given by the developers of the SF-36[32] (Table 5). This reference sample was selected

TABLE 2. *Visual Analog Scale Values for Pain*

	Baseline	7-10 Days	4-6 Weeks	3 Months	6 Months	1 Year†	2 Years‡
VAS score							
Median (range)	8 (5-10)	3 (1.5-5)	2 (0-7)*	1.5 (0-4)	1 (0-1)	1 (0-1)	0.7 (0-1)
VAS = 0	0	0	2 (15%)	3 (23%)	5 (38%)	4 (33%)	5 (42%)
VAS ≤ 1	0	0	4 (31%)	5 (38%)	13 (100%)	12 (100%)	12 (100%)
VAS change from previous time point							
Mean ± SD	—	−5.2 ± 1.7	−0.8 ± 1.2	−0.5 ± 1.9	−1.0 ± 1.1	0 ± 0.4	0 ± 0.7
99% confidence bounds§	—	−3.8, −6.6	−1.8, 0.3	−2.2, 1.1	−1.6, −0.3‖	−0.4, 0.4	−0.6, 0.6

*At 4 to 6 weeks, 1 patient reported VAS of 7 (see text).
†N = 12; the missing patient returned for follow-up at 16 months and reported continued resolution of pain.
‡N = 12.
§Mean of differences between subsequent time points: [t_1 - (α/2) (SD of mean of differences/square root of n)], where (α/2) = .995 and t_1 - (α/2) = 3.0545, to obtain bounds equivalent to ($P \leq .01$).
‖Statistically significant improvement from 3 months, $P \leq .01$.

because it most closely approximated our study patients in age. At baseline, all Principal Components scores related to physical functioning were lower (i.e., worse) than the U.S. reference sample.

MRI Findings

At baseline, 11 of 13 patients had MRI findings consistent with tendinosis; the remaining 2 had no apparent evidence of tendinosis. Six weeks after the procedure, patients showed increased signal changes and evidence of edema limited to the treatment area. No evidence of other soft-tissue or bony involvement was noted. The MRI findings at 6 weeks were as expected and were consistent with observations normally seen following surgery. At 6 months, of the 11 patients who had positive findings of tendinosis on the baseline MRI scan, 10 had complete or near complete resolution of the signal or equivalent scans to baseline and 1 patient had increased postoperative signal changes, although she had improved clinically from baseline. At 12 months, 9 of the 11 patients who had signal change consistent with tendinosis at baseline returned for a follow-up MRI scan. All 9 patients showed improvement. A representative MRI series is presented in Fig 2.

TABLE 3. *Grip Strength (pounds of force)*

	Untreated Arm	Treated Arm	Difference
Baseline	82.8 ± 35.9*	61.4 ± 32.6	21.4 ± 30.7†
4-6 weeks	80.6 ± 36.2	79.2 ± 31.1	1.5 ± 18.2†‡
6 months	84.0 ± 30.5	85.3 ± 33.5	−1.3 ± 9.8‡

*Mean ± SD.
†P = .019, dependent t test, df = 12.
‡P = .572, dependent t test, df = 12.

Return to Preinjury Level of Activity

There were 5 athletes (1 professional and 4 recreational) and 8 patients with work- or activity-related conditions. For all patients, return to preinjury activity level averaged 4 to 5 weeks, ranging from 2 days to 4 months. Results for the athletes did not differ from the other patients.

DISCUSSION

At baseline, all of our patients had failed a number of conservative measures. Following RF-based microtenotomy for chronic tendinosis, all patients reported at least some pain relief within the first 7 to 10 days, which continued through the first year after the procedure. Simultaneously, limb function and quality of life scores were also improved. All 13 patients had good or excellent results through 24 months and beyond.

Surgical standard of care in refractive cases such as ours usually consists of lateral epicondylar release or resection,[2,33] tendon debridement and nerve decompression,[34] excision or debridement of affected tissue,[4,35] or an alternative technique.[36-38] Surgical methods routinely have excellent success rates, up to and exceeding 90%. With straightforward complete release of the common extensor tendon (permitting about a 1-cm distal muscle slide to a new resting length), Goldberg et al.[2] reported that complete pain relief was achieved in 73% of 34 patients; 24% of the remainder had minimal residual symptoms at 4 years

TABLE 4. *Upper Limb DASH*

	Baseline	4-6 Weeks	3 Months	6 Months	1 Year*	2 Years†
DASH Score						
Median (range)	38 (20-59.5)	15 (0-49.2)	8 (0.8-41.7)	2.5 (0-29.2)	0.4 (0-13)	0.8 (0-23)
Change in DASH from previous time point						
Mean ± SD	—	−20.5 ± 13.0	−4.2 ± 17.7	−6.2 ± 6.8	−3.0 ± 5.9	1.3 ± 4.0
99% confidence bounds‡	—	−31.5, −9.5§	−19.1, 10.8	−11.9, −0.41	−8.1, 2.16	−2.2, 4.9

*N = 12.
†N = 12.
‡Mean of differences between subsequent time points: [t_1-(α/2) (SD of mean of differences/square root of n)], where (α/2) = .995 and t_1-(α/2) = 3.0545, to obtain bounds equivalent to ($P \leq .01$).
§Statistically significant improvement from baseline, $P \leq .01$; statistically significant improvement from 3 months, $P \leq .01$.

postoperatively. In patients followed-up over 2 years after the same type of procedure, Rosenberg and Henderson[33] indicated that 18 of 19 patients reported recovery from pain and gained strength at an average of 3 to 4 months after the surgery; pain relief persisted through 2 years postoperatively. Almquist et al.[38] suggested that wide surgical excision with placement of a vascularized rotational pedicle flap of anconeus muscle substantially improved outcomes over simpler surgical resection.

TABLE 5. *Quality of Life SF-36 Principal Component Scores*

Principal Component	Mean (SD)	Range
Physical functioning		
Baseline	45.7 (6.5)	28-53
Month 6	52.2 (8.3)	28-57
Year 1*	51.8 (11.3)	17-57
Year 2†	54.2 (3.9)	47-57
U.S. Data‡	50.0 (9.5)	14-58
Role physical		
Baseline	39.7 (10.6)	20-57
Month 6	52.5 (8.6)	27-57
Year 1	55.2 (3.0)	47-57
Year 2	54.5 (6.1)	37-57
U.S. Data	50.3 (9.9)	17-57
Bodily pain		
Baseline	39.4 (6.9)	29-51
Month 6	52.3 (7.0)	37-62
Year 1	55.6 (4.3)	51-62
Year 2	55.1 (11.9)	20-62
U.S. Data	49.2 (10.1)	19-63
Overall physical		
Baseline	45.1 (7.2)	31-50
Month 6	52.2 (7.4)	32-59
Year 1	53.6 (5.)	39-59
Year 2	54.6 (4.9)	47-60
U.S. Data	49.6 (10.0)	5-69
Overall mental		
Baseline	52.9 (10.1)	32-64
Month 6	55.3 (6.7)	37-61
Year 1	58.4 (3.5)	52-67
Year 2	55.9 (4.7)	43-60
U.S. Data	50.5 (9.9)	6-74

*N = 12.
†N = 12.
‡Sample U.S. population, aged 45 to 54 years.

Similarly good success is reported with surgical debridement procedures. Nirschl and Pettrone[35] reported 85% good to excellent results following excision and repair of the tendinosis affected tissue observed with surgical exposure of the extensor carpi radialis brevis. Wilhelm et al.[34] reported 90% or better success with direct decompression of the radial nerve segment. Despite these good or excellent success rates, open surgery is recognized to have drawbacks, particularly extended recovery (3 to 6 months),[39] unwillingness of patients to undergo it,[40] and potential sequelae associated with restricted function, including increased elbow instability, persistent muscle weakness, and atrophy.[40,41] Arthroscopic procedures have been pursued as a promising and less invasive option, although portal placement is recognized to be technically challenging and fraught with complications.[42,43] Hence, RF-based microtenotomy may provide an excellent alternative to traditional surgical procedures. It is simple to perform, allows early and easy rehabilitation, and was shown in this study to provide rapid pain relief that has persisted through at least the first 2 years following the procedure.

MRI has been reported to be useful for detecting physiologic signs indicating lateral epicondylitis and/or tendinopathy. Potter et al.[44] and Pfahler et al.[45] reported good correlation between MRI and physical observations in simultaneous study of MRI, surgical findings, and histopathology in patients treated surgically for chronic refractive lateral epicondylitis. Postoperative MRI findings from our patients showed complete resolution over baseline in all lateral epicon-

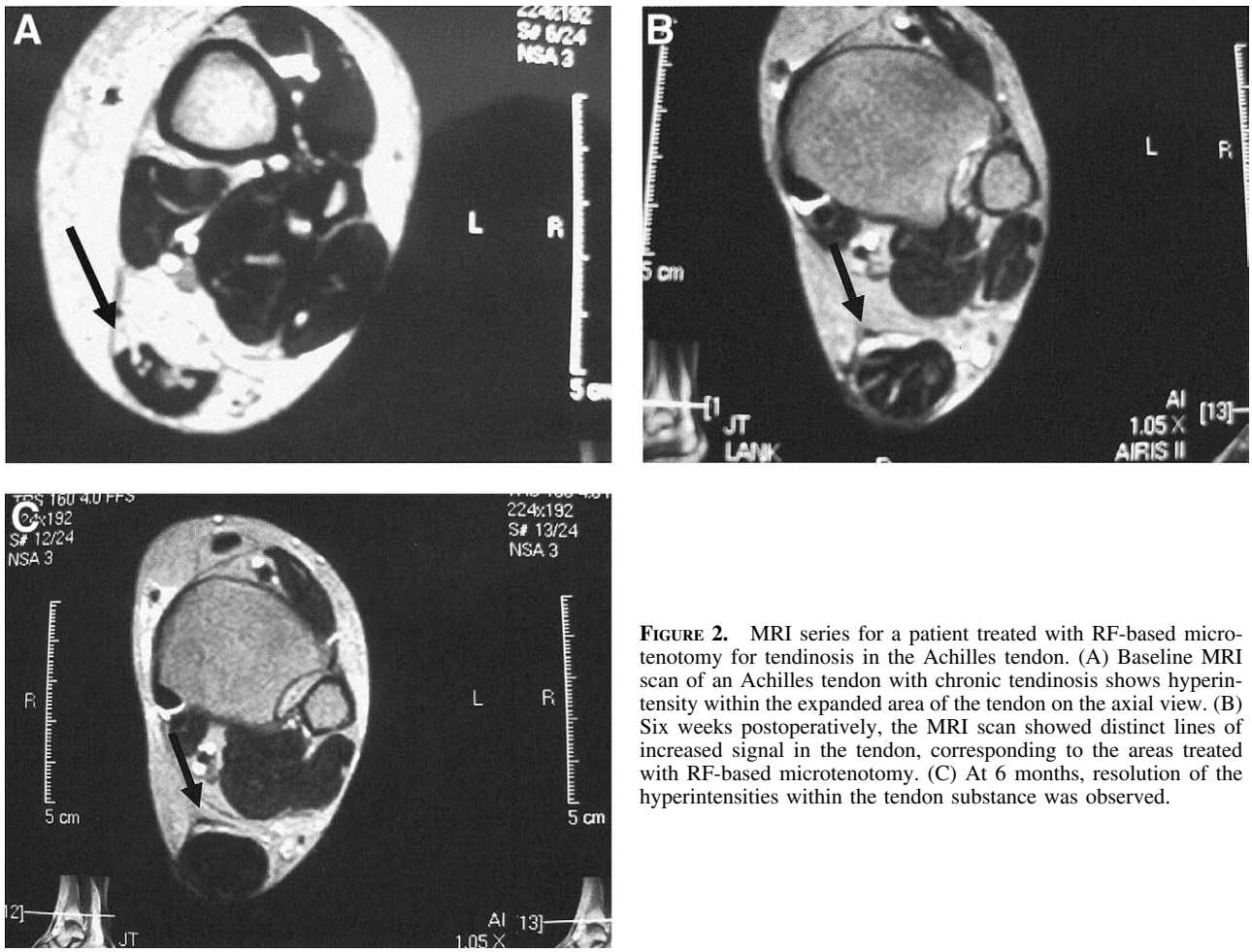

FIGURE 2. MRI series for a patient treated with RF-based microtenotomy for tendinosis in the Achilles tendon. (A) Baseline MRI scan of an Achilles tendon with chronic tendinosis shows hyperintensity within the expanded area of the tendon on the axial view. (B) Six weeks postoperatively, the MRI scan showed distinct lines of increased signal in the tendon, corresponding to the areas treated with RF-based microtenotomy. (C) At 6 months, resolution of the hyperintensities within the tendon substance was observed.

dyle patients. MRI evaluation of patients undergoing treatment for tendinosis of the knee, ankle, or medial epicondyle showed similar resolution in most cases, but occasionally an increased signal or no resolution was observed, even with improved clinical symptoms. Whether MRI is an appropriate tool with which to follow resolution of chronic tendinosis has not yet been established; a literature search rendered no other study using MRI to document resolution of a noted pathology following intervention. In both oncology patients after tumor excision and in patients after a spine surgery procedure, it has been noted that patients may show persistent increased signals in the soft tissues around the surgical site through 2 years. These observations suggest that MRI changes at 18 or possibly even 24 months after tendinosis treatment may more clearly indicate a true return to baseline.

It is unlikely that the dramatic and rapid improvement observed in our patients within the first 7 to 10 days can be attributed to revascularization and reorganization of collagen in the treated tendons in such a short period of time. Hence, we hypothesize that the rapid pain reduction may be caused by an antinociceptive effect, similar to that documented with the use of extracorporeal shock wave therapy.[46,47] At this time, there is no known physiologic mechanism for the antinociceptor response.[48,49] We suspect that this antinociceptor response may be short-lived and is replaced by a longer-term angiogenic response. Evaluation of the healing response after laser and RF-based TMR has indicated that signs of neovascularization are evident by 2 to 3 weeks postoperatively.[19-21] Dietz et al.[19] found that localized vessel count increased substantially between 3 and 9 weeks after RF-based TMR. Past study of the in vivo healing response in muscle following plasma-mediated RF showed this therapy induced a more localized inflammatory response than conventional electrosurgery and was also associated with muscle repair rather than degeneration.[50]

O'Neill et al.[51] more recently reported that discectomy performed using plasma-mediated RF was associated with a beneficial cytokine response in the degenerated disc, notably, significantly increased expression of interleukin-8 (associated with angiogenesis), but decreased expression of interleukin-1 (inhibits cell regeneration).[51] Interleukin-8 is known for its hypalgesic properties and interleukin-1 is a known inflammatory agent.

Although the potential advantages of RF-based techniques over other approaches are attractive, some investigators have expressed concern over excessive tissue damage observed experimentally.[52-54] A series of studies by Lu et al.[52] suggested that the depth of adjacent tissue death in articular cartilage with RF-based devices could be as high as 2,500 μm. In contrast, Kaplan and colleagues[55] indicated that although depth of excavation was increased with exposure to incrementally higher voltage settings, chondrocytes remained viable immediately below the surface of the treatment area, showing no alterations in nuclear, cytoplasmic, or surrounding lacunar structures. In more recent studies evaluating both histology and confocal microscopy in conjunction with metabolic activity in articular cartilage and meniscus, it was found that cell necrosis at the excavation border was less than 150 μm and that metabolic activity of treated samples did not differ significantly from control tissue.[56] Examination of thermal changes with plasma-mediated RF in other medical specialties has shown that the border of thermal change is less with plasma-mediated RF than conventional electrosurgery (e.g., the Bovie).[57,58] In spinovertebral disc tissue, plasma-mediated RF provided a clean void within the nucleus pulposus while inducing minimal adjacent tissue damage and no adjacent cellular damage in the annulus, endplate, spinal cord, or adjacent nerve root.[59] It is well known that electrosurgery can be used to perform several different functions in tissue, including coagulation, desiccation, and cutting; its end effect is modified by modulating current frequency, voltage, and electrode configuration and size. Thus, it is imperative to rigorously control these factors when studying the biological effects of electrosurgery. New developments in measurement techniques as well will aid in this study.

Over the same period of time that data were collected for this prospective study, 7 patients with tendinosis of the medial epicondyle of the elbow and Achilles and patellar tendons were also treated with similar results. Tendinopathies are a widespread clinical problem and it appears that tendinosis, in particular, may not be adequately addressed by treating it using the standard, commonly applied strategies. This preliminary prospective case series showed that treatment of tendinosis using RF-based microtenotomy is safe and that it effectively improved or eliminated clinical symptoms. Of course, future clinical study would necessarily incorporate a control group to control for the placebo effect,[60,61] as well as the other known weaknesses inherent in small studies of prospective case series.[62,63] Currently, a prospective, multisite randomized clinical study is underway. Results of this and other multicenter studies will be necessary to further substantiate our observations.

CONCLUSIONS

RF-based microtenotomy appears to be a safe and effective procedure for treating patients with chronic tendinosis. The microtenotomy is a technically simple procedure to perform and is associated with a rapid and uncomplicated recovery. Pain relief was achieved rapidly in all patients and diminished even further with time.

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