The Journal of Foot & Ankle Surgery xxx (2016) 1–3

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Case Reports and Series

Radial Soundwave for Sesamoidopathy in Athletes: A Pilot Study

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ARTICLE INFO

Level of Clinical Evidence: 3

Keywords:
avascular necrosis
bipartite sesamoid
sesamoidectomy
sesamoiditis

ABSTRACT

The purpose of the present study was to evaluate the efficacy of radial soundwave therapy (RSW) for the management of sesamoiditis, symptomatic bipartite sesamoids, and avascular necrosis in athletic patients. The data from 10 patients undergoing RSW for sesamoiditis were retrospectively studied. Three treatments at 2.4 Bar and 13 Hz, for a total of 2500 pulses in each session, were administered to the affected sesamoid approximately 1 week apart. The Roles and Maudsley score and the visual analog scale (VAS) were used to assess disability and pain. An overall improvement was seen in reported pain after RSW. The pretreatment VAS score was 5.9 ± 1.7 and the post-treatment VAS score improved to 2.3 ± 2.4 ($p = .0001$). The activity pretreatment Roles and Maudsley score was 3.1 ± 0.3 and the post-treatment score was 1.5 ± 0.7 ($p = .00003$). All but 1 of the patients (90%) reported some or complete relief of pain. The mean time to return to activity was 10.1 ± 15.6 weeks, although this value was biased by 1 patient requiring 1 year to return to activity. Eliminating this patient, the average time to return to activity was 5.4 ± 5.6 weeks. Three patients in the cohort did not have to stop their desired activity at all, including 1 gymnast and 1 runner. Of these 3 patients, 2 (20% of all patients) reported complete relief of pain (VAS score of 0) after treatment. The third patient experienced a significant decrease in pain, with the VAS score, improving from 7 to 1. The results of the present study have demonstrated that RSW can be a viable treatment of certain symptomatic sesamoid pathologies and can be considered a valid alternative to surgery.

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The term "sesamoiditis" refers to inflammation or irritation of either the tibial or fibular sesamoid bones located within the flexor hallucis brevis tendon at the level of the first metatarsophalangeal joint and can also refer to inflammation of the joint capsule surrounding the bones (1). The sesamoids articulate with the plantar aspect of the first metatarsal head and are connected to the metatarsal head by collateral ligaments (2). The sesamoid complex can transmit ≤50% of body weight and during toe off can transmit loads >300% of body weight (3).

Acute injuries to the sesamoids can be caused by sudden and violent dorsiflexion of the hallux or first MTPJ, and chronic injuries can be due to repetitive stress such as running or jumping. Forced dorsiflexion of the hallux can also disrupt the sesamoid apparatus, causing the bones to dislocate (4). Football players, soccer players, basketball players, and dancers often demonstrate sesamoid injuries. The tibial sesamoid bears more weight and is injured more often than the fibular sesamoid. Patients with a cavus foot or a plantarflexed first ray can also present with sesamoid pain. Patients will present with pain under the first metatarsal head. If direct trauma has occurred, some slight edema and ecchymosis could be present. Physical examination will reveal pain on palpation along the affected sesamoid, sometimes accompanied by painful range of motion of the first MTPJ (5).

At imaging, plain radiographs can show fractures or the presence of bipartite sesamoids. Ultrasonography can be useful to evaluate inflammation in the surrounding soft tissue. Bone scintigraphy, combined with radiographs, can aid in localizing sesamoid pain. Although highly sensitive, technetium bone scans are not as specific and can show increased uptake in stress reaction, osteonecrosis, osteoarthritis, fracture, and infection. Computed tomography scans can show fractures and degenerative changes and can also be used to evaluate for increased sclerosis such as seen in osteonecrosis.

Financial Disclosure: None reported.
Conflict of Interest: Amol Saxena received a Storz machine and is a speaker for Storz and Curamedix receiving honoraria.

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http://dx.doi.org/10.1053/j.jfas.2016.07.024

Magnetic resonance imaging (MRI) is the most useful imaging modality in the evaluation of sesamoid pathology. MRI findings are relatively specific for infection, osteoarthritis, and fracture, and MRI provides superior evaluation of adjacent soft tissues (6). Single photon emission computed tomography scans have been used and can be helpful to delineate which portion of the sesamoid has been injured.

Conservative management modalities for sesamoid pathologic findings include protection, optimal loading ice, compression, elevation (POLICE) therapy initially, with the goal of reducing hallux dorsiflexion (7). Immobilization, non-weightbearing, and the use of orthotics can be effective in offloading painful pressure areas. ("POLICE" first has been described to replace "PRICE" [protection, rest, ice, compression, elevation] as being more accurate for athletic individuals, because varying degrees of protection [i.e., cast boot with weightbearing, cross-training] is encouraged with sports injury.) Extensions on orthotics, such as Morton's extensions, can be used to minimize first MTPJ movement (8). A "reverse Morton's" or "dancer's pad" can be applied to the orthosis extension to offload the sesamoid. Cortisone injections can help alleviate symptoms but should be generally reserved for more chronic cases (9). For sesamoid stress fractures, 6 weeks of immobilization with a cast or walking boot and restriction of activities for 4 to 6 months have been recommended. However, patients with a stress fracture often undergo excision of the fractured bone (10). This results in "downtime" from sports, which is not ideal for athletic individuals.

Shockwave therapy (SWT) has been used as an alternative to surgery for many pathologic entities. The purpose of the present study was to evaluate radial soundwave therapy (RSW) for sesamoidopathy. We studied the effectiveness of RSW for the management of sesamoiditis, symptomatic bipartite sesamoids, and avascular necrosis (AVN).

Materials and Methods

The data from patients undergoing RSW from January 2012 to October 2013 were prospectively studied. The present study was intended as a nonrandomized pilot study. The institutional review board approved the study, and all patients provided written informed consent. The inclusion criteria were sesamoiditis, including symptomatic bipartite sesamoids, AVN (collectively termed *sesamoidopathy*) and failure of other forms of nonoperative treatment, including inserts, rest, orthoses, immobilization with a cast boot, and corticosteroid injections. All these patients were given the option of RSW or surgery. Preoperative athletic activity was documented. The exclusion criterion was sesamoiditis due to degenerative joint disease of the first metatarsophalangeal joint, overt fracture, or inflammatory arthritis.

A total of 11 patients (average age 33.9 $\pm$ 17.3 years) fulfilled the inclusion criteria and elected to undergo radial RSW. One patient was lost to follow-up, and 10 patients had pre- and post-treatment scores available for evaluation. The Roles and Maudsley score (1 indicating no pain or limitations; 2, mild limitations with activity; 3, moderate limitations with activity; and 4, unable to do any activity without pain) and visual analog scale (VAS; 0, absolutely no pain, to 10, uncontrollable pain) were used to record disability and pain (11).

All 11 patients had tried foot orthoses before treatment, 8 had been immobilized in a boot, and 1 had had an injection before RSW treatment. Three had a diagnosis of a chronic fracture (verified by MRI or computed tomography), 1 had AVN (verified by MRI), and 7 had chronic sesamoiditis. None of the patients had an acute fracture.

Treatment with RSW was performed using a Storz D-Actor 200 device (Storz Medical AG, Taegerwilen, Switzerland). This device produces acoustical sound waves (nonultrasonic) that propagate through tissue in a radial fashion (i.e., radial sound waves). The maximum energy flux density with radial devices is at the applicator head. In contrast, with extracorporeal SWT (ESWT), the energy is focused deeper, at the level of the pathologic tissue. Three treatments at 2.4 Bar, 13 Hz, for a total of 2500 pulses in each session, were administered to the affected sesamoid approximately 1 week apart using a small amount of conducting gel. This energy level was chosen on the basis of other studies treating similar subcutaneous extremity regions. No anesthesia was used. Patients were asked to refrain from taking nonsteroidal anti-inflammatory drugs during the treatment. Activities were permitted as tolerated. Five patients were involved in high-impact sports such as running, tennis, gymnastics, and basketball; the rest of the patients did low-impact activity such as walking. The time to return to activity (RTA) was calculated in weeks and recorded as when the patient had returned to the sport that had typically caused their symptoms. Patients were reassessed at 3 and $\geq$12 months after treatment. The post-treatment assessment was performed by an individual not involved in the actual care of the patient.

Results

Of the 10 patients, 3 were male (30%) and 7 were female (70%); 6 left feet and 4 right feet were treated. A total of 7 tibial sesamoids and 4 fibular sesamoids were treated, with 1 patient receiving treatment for both sesamoids. The post-treatment follow-up period from the index treatment was 22.6 $\pm$ 6.8 months.

An overall improvement was seen in reported pain after RSW, with a pretreatment Roles and Maudsley score of 3.1 $\pm$ 0.3 and post-treatment Roles and Maudsley score of 1.5 $\pm$ 0.7 ($p = .00003$). The pretreatment VAS score was 5.9 $\pm$ 1.7, and the post-treatment VAS score had improved to 2.3 $\pm$ 2.4 ($p = .001$). All but 1 of the patients (90%) reported some or complete relief of pain. The mean time to RTA was 10.1 $\pm$ 15.6 weeks. This included 1 patient who reported her time to RTA as 1 year (52 weeks). Excluding her, the mean time to RTA was 5.4 $\pm$ 5.6 weeks for the other 9 patients. Also, 3 patients in the cohort did not have to stop their desired activity at all, including 1 gymnast and 1 runner. The descriptive data and scores are listed in the Table.

Discussion

RSW could be an effective nonoperative treatment for certain types of sesamoidopathy, especially for athletes. All our patients had had previous forms of conservative treatments fail, including inserts, rest, orthoses, immobilization, and injection. With 9 of the 10 patients (90%) having some or complete relief of their pain, RSW should be considered a valid alternative option to surgery. The mean time RTA of 10.1 weeks (5.4 weeks, if excluding the 1 patient with a RTA time of 12 months) was faster than previous findings from other investigators for "active" and "athletic" patients who had undergone sesamoidectomy for chronic sesamoiditis, with a mean time to RTA of $\leq$12 weeks (12,13). Three of the patients in the present study never stopped their activities during treatment, and 2 of these 3 patients (20% of all 10 patients) reported complete relief of pain (VAS score of 0) after treatment. The third patient experienced a significant decrease in pain, with the VAS score improving from 7 to 1.

Our study did have weaknesses, which are common with clinical studies of active athletes. For example, our investigation did not include a control group nor were we able to administer a placebo. We could not control for other confounding factors, such as changes in activity level, shoe gear, orthoses use (or discontinuation of use), and so forth. Although we included >1 type of sesamoidopathy, all patients had the commonality of "sesamoiditis," whether from a

Table
Patient data

Patient No.	Age (y)	Sex	Side	Sesamoid	RM Score		Activity	Time to RTA (wk)	VAS Score		Follow-up Period (mo)
					Before Treatment	After Treatment			Before Treatment	After Treatment	
1	37	M	R	Fibular	3	1	Running	12	5.5	2	25
2	40	F	L	Fibular	3	1	Pilates	4	7	2	24
3	22	F	R	Tibial	3	1	Running	0	7	1	17
4	55	F	L	Tibial	3	3	Tennis	0.8	8	8	17
5	23	M	R	Fibular	3	2	Yoga	12	6	3	38
6	59	F	L	Tibial	4	2	Walking	8	7	4	27
7	23	M	L	Tibial	3	2	Skateboarding	12	3	2	23
8	53	F	R	Both	3	1	Walking	0	3	0	16
9	15	F	L	Tibial	3	1	Gymnastics	0	5	0	16
10	12	F	L	Tibial	3	1	Basketball/track	52	7	1	23
Mean	33.9				3.1	1.5		10.1	5.9	2.3	22.6
SD	17.3				0.3	0.7		15.6	1.7	2.4	6.8

Abbreviations: F, female; L, left; M, male; Pt. No., patient number; R, right; RM, Roles and Maudsley; RTA, return to activity; SD, standard deviation; VAS, visual analog scale.

previous fracture, AVN, bipartite sesamoids, and other causes of sesamoiditis.

Future studies could be improved in multiple aspects. A clinical trial such as the SWT study for plantar fasciitis Gollwitzer et al (14) could serve as a guide, because it is a level 1, randomized, placebo-controlled, multicenter study. Second, a prospective, randomized placebo-controlled study comparing RSW and sesamoidectomy could be performed. The number of patients could be increased for either of these studies, which would allow for more specific conclusions comparing the functional outcomes, time to RTA, and downtime for both groups.

Other studies have shown good outcomes for AVN in other anatomic regions from treatment using ESWT (15,16). A study comparing the results for RSW versus ESWT could also be useful. Lohrer et al (17) showed that focused ESWT was superior to radial "shock waves" (RSW) in a study of plantar fasciitis. The flux density rendered for each treatment (2000 pulses in 3 visits) was greater (0.20 mJ/mm^2, approximately 3.0 Bar) for the ESWT compared with 0.17 mJ/mm^2 (approximately 2.5 Bar) for those in the RSW cohort (17). A similar study of sesamoidopathy could be conducted. However, pathologic entities of the sesamoids are not common, and multicenter studies with appropriately large cohorts could therefore be difficult to perform.

A final note on sound wave is that the terminology *high* and *low* energy is no longer valid. Schmitz et al (18) performed a thorough review of published studies and concluded such. Both types of technologies, ESWT and RSW have been noted to produce high energy and cavitation. Schmitz et al (18) also found no current scientific evidence to favor ESWT versus RSW.

In conclusion, the present pilot investigation has shown that RSW is a suitable treatment for certain symptomatic pathologic entities of the sesamoids of the first MTPJ. RSW therapy will allow some athletes to continue to train during treatment and can be considered in the treatment algorithm before counseling surgical excision of a sesamoid, unless it has been overtly fractured. Further study is encouraged.

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