Effectiveness of Achilles tendon stretching for the treatment of chronic plantar fasciitis

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Background
Plantar fasciitis is a common cause of heel pain. Its characteristic features are pain and tenderness on the medial aspect of the heel. The purpose of this study was to evaluate the outcome of the Achilles tendon-stretching protocol for patients with chronic plantar fasciitis.

Patients and methods
A total of 24 patients who had chronic proximal fasciitis for a duration of at least 6 months participated in this study. The patients received instructions for an Achilles tendon-stretching program. Pain and functional limitations were evaluated with the Foot Functional Index pain subscale and the American Orthopedic Foot and Ankle Society Ankle–Hindfoot Scale. The patients were re-evaluated after 6 months.

Results
The mean Foot Functional Index baseline scoring was 7.69, whereas its mean scoring at follow-up was 1.44. The American Orthopedic Foot and Ankle Society Scale outcome measures also revealed significant improvement for 22 (91%) patients who practiced the Achilles tendon-stretching exercises regularly. Only two (9%) patients reported little improvement, as they were not compliant with the daily stretching routine.

Conclusion
This study provides an effective, inexpensive, and straightforward treatment protocol for the chronic plantar fasciitis. In addition, compliance may have affected the results if the patients did not perform their exercises regularly.

Keywords:
Achilles tendon, plantar fasciitis, stretching

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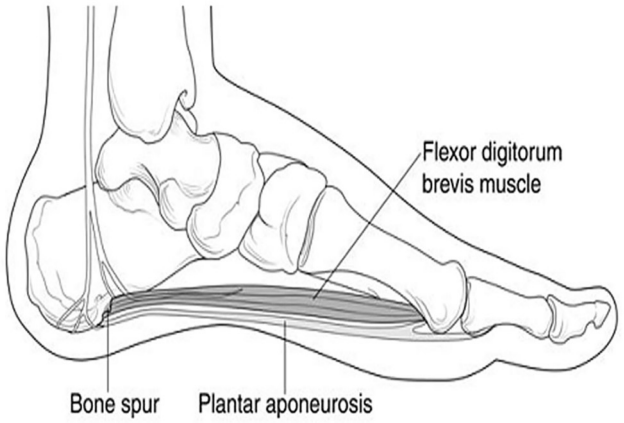
Introduction

Plantar fasciitis can be a painful and debilitating condition that often frustrates not only the patient but also the physician. Plantar fasciitis is defined as an inflammation of the origin of the plantar fascia and surrounding perifascial structures. Despite extensive efforts taken to understand this disorder, foot surgeons continue to debate the source and etiology of plantar heel pain, as well as the most appropriate modality of treatment [1]. The underlying condition that causes plantar fasciitis is a degenerative tissue condition that occurs near the site of origin of the plantar fascia at the medial tuberosity of the calcaneus [2]. The plantar fascia is a thick fibrous sheet of connective tissue that originates from the medial tubercle of the calcaneus, where it then passes over the superficial musculature of the foot, and inserts distally onto the metatarsophalangeal joints, forming the medial longitudinal arch (Fig. 1). The plantar fascia is the main stabilizer of the medial longitudinal arch of the foot against ground-reactive forces, and is instrumental in reconfiguring the foot into a rigid platform before toe-off. Degeneration of the plantar fascia at its calcaneal origin is termed plantar fasciitis [3]. Fibrocartilage is found at the site of origin of the plantar fascia and growing heel spurs appear to take shape deep to the plantar fascia and have been noted to grow within developing cartilage through endochondral and intramembranous ossification, most likely at the site of the enthesis and in close association with the flexor digitorum brevis [4]. It is mostly formed by stimulation of the bone by stress. A study by Pribut [5] has hypothesized that it is caused by sufficient strain in the enthesis and in the calcaneus to stimulate bone and cartilage production. However, a study by Banks *et al*. [6] indicated that calcaneal spurs are coincidental radiographic findings and are not relevant.

After the age of 40, the fat pad begins to atrophy, with loss of water, collagen, and elastic tissue. The overall thickness and height of the fat pad decreases, resulting in diminished shock absorbency and reduced protection of the calcaneal tuberosity [7]. Diagnosis of plantar fasciitis is based on both the subjective and

Figure 1



The incidental 'heel spur' and plantar fascia inserting into the base of the proximal phalanges [1].

clinical examination [8]. The chief initial complaint is typically a sharp pain in the inner aspect of the heel and arch of the foot with the first few steps in the morning or after long periods of nonweight bearing. Usually, after walking ~10–12 steps the plantar fascia becomes stretched and the pain gradually diminishes [9]. There have been several predisposing biomechanical factors reported in the literature: faulty mechanics of the foot due to structural abnormalities, including pes planus, pes cavus, decreased ankle, and first metatarsophalangeal joint range of motion; leg-length discrepancy; lateral tibial torsion; and femoral anteversion [10]. Other risk factors of plantar fasciitis include age-related degenerative changes, overweight, training errors, and occupations involving prolonged standing; those falling into this category include teachers, construction workers, cooks, nurses, military personnel, and athletes training for long-distance running events [6]. In the presence of these risk factors, excessive tensile forces may cause microtears in the plantar fascia. Repetitive trauma to the plantar fascia exceeding the fascia's ability to recover may lead to degenerative changes and an increased risk for injury [11].

Individuals with plantar fasciitis typically see resolution of symptoms within 6–18 months with rest or interventions, but ~10% of patients have symptoms that persist for an extended period of time [3]. Approximately, 85% of patients fully recover or see a significant decrease in their symptoms with nonsurgical treatment [12]. A variety of conservative treatments have been identified for the treatment of plantar fasciitis, including shoe modifications, prefabricated and custom orthoses, stretching exercises, manual therapy, night splints, anti-inflammatory medication, cortisone injections, and immobilization through casting [13]. Foot orthoses are often used to support foot arches, optimize load distribution through the foot, decrease pressure from the origin of the plantar fascia, and improve biomechanical motion during gait [14]. They have been shown to reduce pronation of the foot and collapse of the longitudinal arch, two predisposing factors for plantar fasciitis [15]. However, some conflicting results have been reported regarding the use of orthotics. A study by Landorf *et al*. [15] reported minimum short-term and negligible long-term benefits from the use of customized or prefabricated orthoses over sham orthoses. In contrast, in a randomized clinical trial with 236 participants, Pfeffer *et al.* [16] reported significant improvement in pain and function with the use of prefabricated over custom-made inserts. Night splints are also designed to stretch the Achilles tendon and prevent the overnight tissue contracture, which is probably the cause of morning pain [17].

However, active stretching of the plantar fascia and Achilles tendon is frequently used to treat the condition of plantar fasciitis [10]. Two previous randomized controlled trials have compared two active stretching interventions for plantar heel pain: calf stretching compared with plantar fascia stretching [12] and sustained calf stretching compared with intermittent stretching [18]. Neither trial included a sham or no-treatment control group, and thus the effect of calf muscle stretching by itself has not been examined. An understanding of the anatomy and kinematics of the foot and ankle, the static and dynamic function of the plantar fascia during ambulation, and knowledge of the contributing risk factors associated with plantar fasciitis aid in developing a proper treatment and preventative protocol for this condition [12]. The purpose of the present study was to evaluate the effectiveness of the Achilles tendon-stretching exercise for the treatment of pain and functional limitations in individuals with chronic plantar fasciitis.

Patients and methods

A total of 24 patients with plantar fasciitis were managed with Achilles tendon stretching from March 2008 to April 2010. All patients underwent clinical evaluation to confirm the diagnosis of plantar fasciitis. Fourteen patients were men, and 10 patients were women. The mean age at the time of presentation was 45 years (range: 30–55 years), and all had chronic heel pain for more than 6 months. The patients completed the background information and a history profile of the heel pain. The background information included age, sex, foot affected, weight, BMI, hours spent standing during the day, duration of symptoms, and types of prior treatments. Demographics of participants are shown in

Table 1. Patients were included if they had heel pain lasting more than 6 months. Only those patients who reported pain and tenderness over the medial aspect of the heel/foot were included in the study. Patients were excluded from the study if they had plantar heel pain lasting more than 2 years, if they had a history of systemic disease, a previous surgical release of plantar fascia, or prior heel surgery.

A physical examination was conducted to confirm the clinical diagnosis of proximal plantar fasciitis. Patients who met the inclusion criteria were included in the study. All patients were examined radiologically by using X-ray of the heel to exclude other pathologies (Fig. 2). All patients had received previous conservative treatment including NSAIDs, injections, and/or activity modifications. If both heels were painful, only the most symptomatic heel was used in the study.

Patients received instructions on standing during the Achilles tendon-stretching program. They were taught to perform the stretching while standing and leaning onto the wall with the affected leg placed behind the contralateral leg. Patients were told to bend the front knee while keeping the back knee straight and the heel firmly on the ground (Fig. 3). Patients were instructed to hold each stretch for a count of 10 and to repeat it 10 times at each session. The patients were instructed to perform the stretching program three times per day. Patients controlled the amount of stretch and gradually increased stress load as tissues achieved relaxation. Gradually applied loads could result in tissue relaxation in a more ductile manner. They were asked to perform the stretching protocol for a minimum of 3 months, and thereafter as pain necessitated. The patients were also asked to discontinue any previous therapy that they were receiving for the heel pain. In addition, patients were instructed to use prefabricated soft insoles and a 3-week course of a NSAID. Participants were asked to keep a daily log to monitor their progress, pain level, and adverse effects. All patients were noticed to ensure that they were carrying out the exercises correctly.

Table 1 Demographic information of participants

Variables	Patients (n = 24)
Age [mean (range)] (years)	45 (30–55)
Weight (range) (kg)	82–110
BMI (mean) (kg/m^2)	32
Hours spent standing during the day (mean)	8
Period of symptoms [median (range)] (months)	13 (6–18)
Sex [n (%)]	
Men	14 (58.3)
Women (%)	10 (41.7)
Foot affected [n (%)]	
Right	16 (66.7)
Left	8 (33.3)
Prior intervention	Yes

Figure 2

Calcaneal spur is a coincidental radiographic finding and is not relevant.

Outcome measures

All patients returned for a follow-up examination and completion of the assessment. At the follow-up visits, patients were also asked to rate the change in the pain between the initial and follow-up visits, as well as their perceptions of overall improvement from the beginning of the study. The two primary outcome measures were the Foot Functional Index (FFI) pain subscale [19], and the American Orthopedic Foot and Ankle Society (AOFAS) Scale [20]. The FFI scale is a 0–9-cm visual analog scale, with 0 being 'no pain' and 9

Figure 3

Achilles tendon-stretching exercise. The patient was instructed to place the affected leg behind the contralateral leg and to bend the front knee while keeping the back knee straight and the heel firmly on the floor.

being 'the worst pain imaginable'. The patients were asked to write a number on the line where their pain rating fell. The sum of these scores was then used as a primary pain score to express the overall pain. Only the first seven items were used to generate an overall pain score. The remaining two items on the pain subscale were related to orthotic use and were not relevant to the patients of this study. The seven items on the FFI for pain were averaged to obtain an overall pain rating for each patient. The average patient weight and age were also calculated. The AOFAS Ankle–Hindfoot is a 100-point scale that consists of three parts: pain, function, and foot alignment. The scale consists of nine items that assess both pain and function. The first five items on the scale are subjective measures of pain and function that can be filled out by the patient. The last four items are physical measurements taken by the examiner: gait, sagittal motion, hindfoot motion, and ankle–hindfoot stability and alignment.

Statistical analysis

The seven items on the FFI for pain were averaged to obtain an overall pain rating. Objective measure included AOFAS Ankle–Hindfoot Scale (100 points total). It was carried out by using the paired *t*-test for differentiation between baseline and follow-up variables. The difference was considered statistical significance at a *P*-value of less than 0.05.

Results

At the 6-month follow-up evaluation, complete data were obtained from 24 patients. There were no patients lost to follow-up. All patients were managed with the Achilles tendon-stretching program. Most patients improved significantly with subjective pain rating and objective measures over time. At the 6-month follow-up, all patients had significant pain reduction compared with the initial baseline pain. The responses based on pain, function, satisfaction, and need to seek additional treatment demonstrated an overall positive response. Patients were questioned about their compliance with the frequency of the exercise program. This revealed that most patients performed the stretching exercises as advised. A total of 22 (92%) patients performed the stretching protocol as prescribed. Ten (41%) patients had no residual pain, with 0 FFI scoring. For 12 (51%) patients pain improved significantly, with FFI scoring less than 4. They reported they had done the exercises daily, three times a day. But, only two (8%) patients were not compliant with the daily stretching protocol, and only these two reported little improvement; their FFI scoring was 5.2 and 6.1, respectively. They could not return to their normal levels of activity, as pain interfered substantially with their daily activities. One (4%) of these two patients reported seeking treatment by a physical therapist. The other one (4%) reported the need to seek additional treatment. However, none of them underwent surgery.

Analysis of subject measure

The overall pain rating from the pain subscale of the FFI improved as compared with baseline. Morning pain (item 2), the most important feature of plantar fasciitis, was analyzed separately from the FFI pain subscale. All patients reported a decrease in morning pain. The mean FFI baseline scoring was 7.69, whereas the mean FFI scoring at follow-up was 1.44 (Table 2). This difference was statistically significant ($P < 0.05$).

Analysis of objective measure

The objective measures also improved from baseline for all patients. The mean AOFAS scoring changed significantly from 48.79 at baseline to 91.33 at follow-up. This difference was statistically significant ($P < 0.05$). No adverse effects were reported by the patients.

Table 2 Outcomes at baseline and follow-up

Patient nos	Visual analog score (Foot Functional Index) [19]		AOFAS	
	Baseline	Follow-up	Baseline	Follow-up
1	6.8	0	64	100
2	7.7	2.1	52	88
3	6.9	1.3	43	84
4	7.6	0	44	100
5	8.7	3.1	69	82
6	8.5	1.5	45	84
7	8.1	0	68	100
8	6.8	0	55	100
9	9.1	5.2	36	70
10	7.3	0	43	100
11	7.8	1.5	44	92
12	7.5	0	43	100
13	6.6	2.4	42	82
14	8.7	2.8	58	84
15	7.8	0	42	100
16	9.0	6.1	67	66
17	6.8	2.0	52	90
18	7.7	1.5	43	98
19	7.6	1.6	45	96
20	7.5	0	38	100
21	7.5	0	39	100
22	6.5	1.5	44	90
23	7.2	0	42	100
24	8.9	2.0	53	86
Mean	7.69	1.44	48.79	91.33
Median	7.60	1.5	44	96
SD	0.78	1.65	9.88	9.98

AOFAS, American Orthopedic Foot and Ankle Society Scale [20].

Discussion

Plantar fasciitis is a common clinical problem. Despite this, there has been remarkably little advancement in the understanding and treatment of this frustrating condition. Plantar fasciitis is generally regarded as a self-limited condition, with more than 80% of the cases resolving within 12 months, regardless of therapy. A variety of treatment options are available to patients [21].

The diagnosis of plantar fasciitis is made clinically in most cases. A history of 'start-up pain', the typical history of pain after a period of rest, and tenderness at the plantar medial aspect of the calcaneus support the diagnosis. Risk factors include biomechanical abnormalities of the foot, increased body weight, middle age, and repetitive stress. Additional findings after a thorough interview and physical examination of the patient may warrant the use of plain radiographs or advanced imaging to rule out other possible diagnoses [21,22]. Frequently, patients come into the office with radiographs showing a heel spur and request to have it removed. The physician should attempt to minimize the role of the so-called spur, which often requires counseling to dispel myths that the patient was told from friends or other clinicians. The heel spur commonly seen on radiographs is thought to be a result of the problem and not the cause [1]. The most prudent approach to therapy is to employ conservative treatment first. Primary considerations for treatment should include temporary refrain from intense weight-bearing activity as much as possible; avoidance of walking barefoot on hard surfaces; and replacement of any worn or ill-fitting shoes with new, more accommodating footwear. Stretching exercises can be beneficial for treatment and prevention of recurrence [1].

The purpose of this study was to examine the effectiveness of the Achilles tendon-stretching exercise for the treatment of plantar fasciitis. The results of the present study show that this mode of treatment is beneficial for reducing pain and dysfunction associated with plantar fasciitis. The patients were instructed to perform the stretching program three times per day. These exercises should be done just after getting out of bed in the morning, in the afternoon, and before bedtime, as well as after any period of prolonged sitting. Patients were instructed to hold each stretch for a count of 10 (or with a 30-s hold) and to repeat it 10 times at each session. They also performed their stretches manually. However, longer stretching time may have resulted in better tissue relaxation and subsequently provided pain relief. Overall pain reduction and functional improvement were noted as early as 8 weeks of intervention. The patients were able to maintain early gains in pain reduction and functional improvement for the remaining intervention period. The patients showed initial rapid improvement in overall and morning pain and then leveled off.

The data of the present study indicate that more than 90% of the patients were satisfied and experienced a reduction in symptoms. Furthermore, the chance of returning to full activity, as well as the chance that no further treatment would be needed, was greater than 75%. These results are particularly encouraging when considering the high level of pretreatment pain, as depicted by the visual analog scale scores, and the fact that all patients had had chronic symptoms for at least 6 months.

Noncompliance with the daily stretching exercises was an important contributory factor affecting the results of the involved patients. The past history of failure of the previously tried treatment options by the patients was a critical factor that led them to give up; thus, they stopped the stretching protocol suddenly without seeking medical advice. They thought that their severe pains could not be stopped by the stretching protocol. The patients had BMI mean over 30, indicating that most of the patients were overweight or obese.

The old adage, 'The more treatments available for a condition, the less effective any of them is', certainly applies to plantar fasciitis. Prolonged symptoms of plantar fasciitis may lead to further treatments, including surgical intervention. Surgical treatment with partial plantar fascia release with nerve release has resulted in mixed outcomes [21]. In their study, Davis *et al.* [23] reported that less than 50% of the patients with chronic heel pain were totally satisfied with the results of surgical intervention. Although a study by Conflitti and Tarquinio [24] noted a high satisfaction rate; only 57% of their patients had no functional limitation postoperatively. However, despite varied surgical methods, the typical recovery is prolonged and often does not allow for full function. Surgery should only be considered for patients with considerable disability, for whom conservative treatment has not helped after at least 12 months. When fasciotomy is necessary, partial release of less than 40% is recommended [25]. Consequently, it is important to further optimize nonoperative treatments before considering surgical options. However, efficacy of these treatments is questionable. Furthermore, because of the natural history of this condition and the lack of high-quality evidence to support one particular intervention, the initial treatment of plantar fasciitis should be limited to nonoperative methods. Nonsurgical treatment of proximal plantar fasciitis has a reported success rate of

85–90% [22]. The clinician needs to inform the patient that it may take as long as 6–12 months for all pain to resolve. The majority of the nonoperative treatments for plantar fasciitis have demonstrated positive or encouraging results, although a long duration of symptoms is not uncommon. These modalities include night splints [26], prefabricated and custom-made inserts, shoe modifications, stretching exercises, cortisone injections, application of a cast, extracorporeal shock wave therapy [27], magnetic insoles, or any combination of these modalities. NSAIDs are used conventionally for temporary pain relief, but offer no support for resolution of the condition.

A study by Pfeffer *et al*. [16] reported the use of prefabricated orthoses in combination with Achilles stretching as the most effective treatment regimen for people with acute plantar fasciitis (<6 months). Night splints are often used to treat plantar fasciitis symptoms and designed to place constant load on tissue for an extended period of time using creep property. In contrast, a study by Probe *et al.* [26] reported no benefit from night splinting. Similarly, a study by Martin *et al.* [28] compared the efficacy of night splinting with that of over-the-counter and custom-made orthosis and reported no difference between groups for pain and function. In addition, poor compliance was reported in the study. Treatment with a night splint has shown especially encouraging results in well-designed, prospective, randomized studies. Although limited to short-term follow-up, the splints have been shown to be effective for recalcitrant plantar fasciitis in the majority of patients.

In a controlled study of the short-term and long-term effectiveness of high-energy shock wave treatment for chronic plantar fasciitis, a study by Ogden *et al.* [27] reported that 77% of all patients who had one or more treatments showed good or excellent results. Furthermore, the evidence currently available to assess the efficacy of extracorporeal shock wave therapy lacks the quality and consistency to support its unconditional use in the management of plantar fasciitis.

Corticosteroid injections provide temporary relief from pain and are recommended only in extreme cases, as they may increase the risk for infection and contribute to further degeneration of the plantar fascia and heel fat pad. Again, the risk for fascial rupture or fat pad atrophy weighs against repeated or the immediate use of injections. Alternatively, nutritional considerations such as vitamin C, zinc, glucosamine sulfate, bromelain, and fish oil may be incorporated to address the pain and inflammatory symptoms associated with plantar fasciitis, and to help support the healing process systemically [22].

Stretching exercises are preferred by many practitioners. Previous studies have reported positive results from Achilles and plantar fascia stretch [12,16,29]. A study by Wolgin *et al.* [30] reported successful results for 83% of their patients, and, in their study, Davis *et al.* [23] reported that stretching was their most effective conservative treatment. Stretching exercises may also benefit patients with a tight Achilles tendon, a group who are known to be at risk for plantar fasciitis. Furthermore, a study by Digiovanni *et al.* [29] has shown that a tight calf muscle and Achilles tendon are the main contributors to the condition. Therefore, the cornerstone of a lasting, effective treatment program is aggressive stretching of the calf muscle. The advantages of these modalities are relative ease and minimal expense when self-administered by the patient [21]. In contrast, a study by Radford *et al.* [31] reported no beneficial effects from Achilles stretch. In their study, the authors used a wooden wedge that was placed under the foot to allow calf muscle stretch for a total of 5 min/day.

The results of the present study were in contrast to the results reported in a study by Digiovanni *et al.* [29], who hypothesized that patients with chronic plantar heel pain who are managed with a tissue-specific plantar fascia stretching protocol have a better functional outcome after 8 weeks of treatment compared with that after a standard Achilles tendon-stretching protocol.

Stretching exercises, although central to most treatment protocols, have rarely been evaluated in isolation or for their long-term benefits. In evaluating the data from the present study, an overall positive response to the Achilles tendon stretching was noted. In regard to pain and the visual analog scale scores at the 6-month follow-up evaluation, patients showed significant improvement from baseline. At the 6-month follow-up, these changes from baseline were significant ($P < 0.05$). The trend of improvement, as shown by the slope of the changed scores, suggests that the Achilles tendon stretching was a major contributor to this improvement.

The majority of the patients in the current study achieved the best results within 6 months, with a small percentage improving in subsequent months. Consequently, the use of the Achilles tendon-stretching protocol for 6 months is recommended, and if it is not successful at that point, then another treatment approach should be pursued. In the present study, the FFI [19] pain subscale and the AOFAS Scale [20] were used to evaluate the results. Both scoring systems are universally accepted.

The strengths of this study are based on its original prospective, randomized design. In addition, stringent

patient inclusion criteria were used. If patients did not exhibit the classic signs and symptoms of proximal plantar fasciitis, including tenderness localized to the medial calcaneal tubercle and pain with the first steps in the morning, they were excluded from the study. In addition, patients with chronic symptoms for at least 6 months were intentionally chosen to minimize the effect of a natural improvement based on the passage of time, which is often noted in individuals with acute plantar fasciitis.

The results of this study were obtained for patients who had experienced chronic symptoms associated with plantar fasciitis, and who had used multiple interventions before using the Achilles tendon stretching. Results of this study show that Achilles tendon stretching is effective at treating the pain and functional limitations associated with chronic plantar fasciitis. For patients with chronic proximal plantar fasciitis, this study reinforces the value of the Achilles tendon-stretching protocol.

The protocol used in the present study seemed to be effective for enrolled patients for the treatment of plantar fasciitis. However, the current study has some limitations, including a small sample size, and a short follow-up period. Difficulty in recruiting patients who met the criteria and who were willing to participate led to the small sample size. Future studies should examine the effectiveness of the Achilles tendon stretching with larger sample size and determine whether one method is more effective than the other as a treatment of plantar fasciitis. The short follow-up period questions the long-term effects of the Achilles tendon stretching. It would be beneficial for future studies to include a measure of compliance of Achilles tendon stretching and longer follow-up period. Difficulties with the retention of patients, compliance with the prescribed program, and the lack of an untreated control group limit the capacity of this study to determine whether variations in stretching techniques affect the natural history of plantar fasciitis.

Conclusion

Achilles tendon stretching can significantly reduce global measures of pain and disability for patients with chronic plantar fasciitis. This study provides an effective, inexpensive, and straightforward treatment protocol for the treatment of chronic proximal plantar fasciitis. In addition, compliance may have affected the results if the patients did not perform their exercises regularly.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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