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Tuli's—A Dynamic Heel Cup Which Effectively Reduces the Shock of Heel Strike

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INTRODUCTION

It is the intention of the authors of this paper to introduce a revolutionary new foot device which may be employed as a primary or adjunctive method of treatment for a myriad of painful foot and leg conditions. The TULI's dynamic heel cup is the culmination of three years' developmental research and clinical experimentation directed towards reducing the phenomenon of shock at heel strike.

During the evolutionary process, primates underwent numerous physiologic changes in a relatively short period of time. In an arboreal existence, body locomotion is distributed to both the upper and lower extremities, often with the former playing the dominant role. As primates evolved to a terrestrial existence, bipedism replaced quadripedism. "Thus, with the entire function of body locomotion transferred upon the lower extremities, not only were they [the lower extremities] required to assume all of the stress of body weight, but also they had become adapted to maintain the vertical posture of the body in stable equilibrium over a greatly reduced area of ground support."[1]

The numerous musculo-skeletal functionally-adaptive changes that took place in the foot, leg, pelvis, and spine, may in no uncertain terms be attributed to the reactive forces of gravity and the perfection of locomotory advantage. We are all aware of the body's effort in its marvelous adaptation to reduce the forces of shock transmitted through the lower extremities during ambulation. These adaptations range from the development of accentuated muscular deceleration to sub-talar joint pronation, and flexion at the knee. But the amalgamation of these evolutionary adaptations in human locomotion are ineffective, and most certainly compromised in modern civilization's unyielding walking surfaces.

The lower extremity was designed neither to be placed into restrictive stockings and shoe gear, nor to ambulate on miles of concrete, asphalt, tile, and hardwood floors. It is no surprise that orthopedists, podiatrists, and general practitioners are seeing increasing numbers of patients with musculo-skeletal complaints. It is our contention that the vast majorities of these conditions, which we shall discuss briefly, are intimately related to one particular aspect of the gait cycle, this being heel strike.

No matter how effective the musculature of the anterior and posterior groups is in limb deceleration, or the sophistication of its joints in their locking and unlocking mechanism to reduce shock, micro-trauma

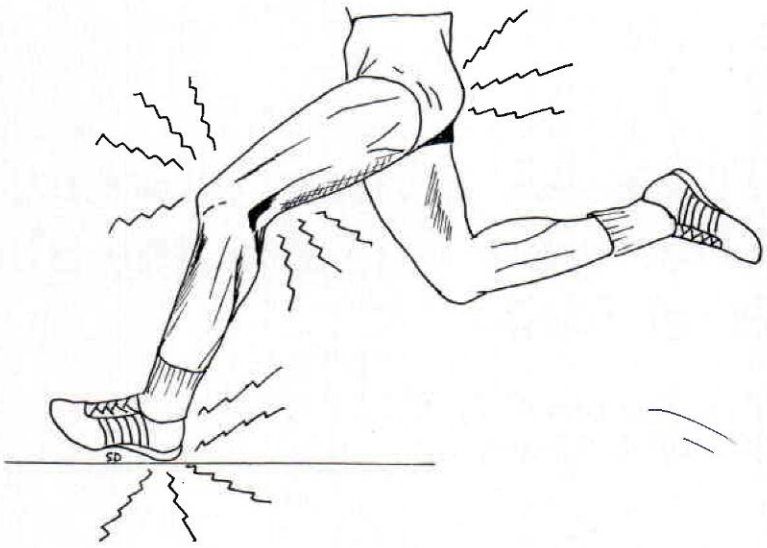

Figure 1. Lower extremity during heel strike. Arrows indicate various segments of the lower extremity: heel, subtalar joint, ankle, knee, hip, and lower back.

occurs and will continue to occur on unyielding surfaces unless protection is offered at the point of contact. This is especially true in the case of athletes who are subject to far more stress than the individual engaging in normal activities. It has been estimated that the force exerted at the point of heel contact in jogging on a level terrain is approximately 3 G's, while it may be increased to 4 G's on a downhill course.[2] Assuming that 4 G's equals four times the body weight and the average man weighs 150 lbs., then the force exerted upon heel strike is 600 lbs./sq.in. Furthermore, the heel strike occurs an estimated 1600 times in the course of one mile, producing 960,000 lbs. pressure at the point of contact over an average jogging time of eight minutes.

The tremendous force of shock during heel strike is dissipated proximally to the sub-talar joint, ankle, knee, hip, and lower back (Figure 1), and is contributory in producing many of the following conditions:

1. Calcaneal apophysitis—(children 8-13 years). Also known as Sever's disease. This condition, according to Tachdjain, is not an osteochondrosis. It is an "irregularity of ossification and sclerosis of the apophysis and is a normal roentgenographic finding."[3] O'Donogue disagrees and states that apophysitis of the calcaneous is aseptic necrosis of the calcaneal epiphysis. *"Faulty circulation is manifested by sclerosis of the epiphysis, frequently accompanied by fragmentation, but the condition is self-limited and usually does not demand drastic treatment. Symptomatically, there is pain at the posterior point of the heel, usually somewhat below the actual attachment of the tendo-Achilles. Pain is elicited by a forcible activity, so that the adolescent can usually go about his regular activity without trouble, only to have recurrence of pain if he starts to run or jump or violently exercise his foot."*[4]

2. Heel spur—an exostosis of the plantar calcaneal tuberosity, the etiology of which is attributed to plantar fascial strain often associated with abnormal pronation.[5]

3. Heel neuroma—perineural fibrosis of the medial calcaneal nerve as described by Davidson is the result of microtrauma. This condition can be extremely painful and neurectomy is the treatment of choice.[6]

Other conditions which are related to the shock of heel strike are disturbances of the forefoot such as metatarsalgia, plantar fascial strain, shin splints, chondromalacia, and hip and low back pain. In the past we have treated the aforementioned conditions with numerous conservative, mechanical, and surgical methods. There are times when surgery is indicated, e.g., chronically symptomatic calcaneal spurs, nerve entrapment syndrome, heel neuroma, knee pain due to a torn meniscus,

etc.; however, surgical intervention is no panacea and certainly no substitute for aggressive conservative treatment.

In our 15 years of clinical experience in shock absorption, we have tried numerous materials and combinations of materials with less than satisfactory results. These include 76 types of padding materials including felt, sponge, airfoam, polyurethane, and a variety of polymer/catalyst preparations. It was due to our frustrations in the conservative treatment and management of the aforementioned conditions that we set out to develop a "true" shock absorbing device.

In the past, primary emphasis has been placed on the biomechanical control of pronatory forces, rather than the reduction of shock at heel strike. After three years of scientific research and mechanical testing, we have developed a unique device, designed to reduce shock to all segments of the lower extremity.

The device itself resembles a heel cup. However, its key feature is a ribbed design on the plantar-posterior aspect, which effectively crushes upon impact. Constructed of a high quality natural latex rubber, it completely rebounds with 100 percent memory (Figures 2 and 3).

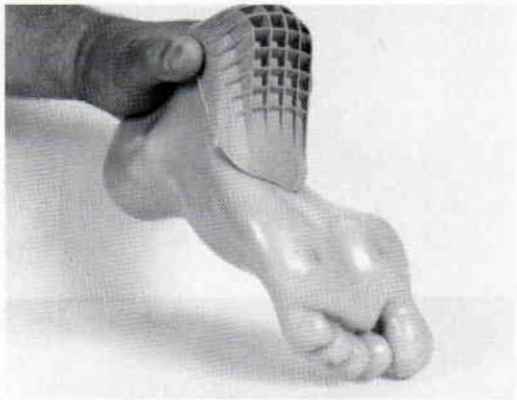

Figure 3. Tuli as applied to bottom of foot.

Figure 4. Tuli may be placed in any shoe.

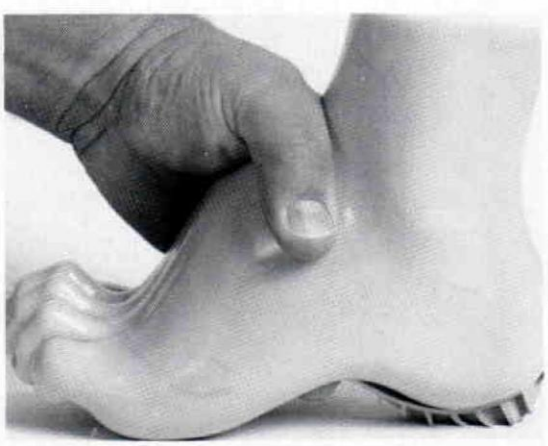

Figure 2. Demonstrating (cross section Tuli) ribs depressed in heel strike.

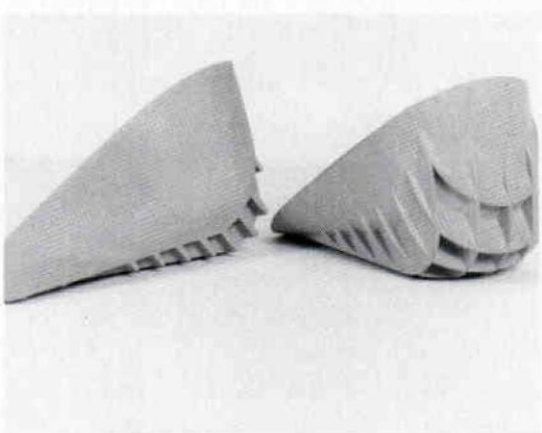

Figure 5. (left) Cross-section side view, showing Tuli rib structure. (right) Complete Tuli, back view.

Preliminary Trial

Patient	Foot Condition	Age	Wgt. (lbs.)	Sex	Duration of SX's
1. R.G.*	Apophysitis Bil.	11	89	M	2 weeks
2. A.G.*	Apophysitis Bil.	13	99	M	3 weeks
3. D.R.*	Apophysitis L	14	94	M	1 year
4. S.R.*	Apophysitis Bil.	12	93	F	3 weeks
5. M.R.*	Apophysitis Bil.	14	110	M	3 years
6. M.B.*	Heel Neuroma R	64	160	F	6 months
7. R.G.	Heel Neuroma L Heel Spur	46	250	M	2 months
8. Jog A	Shin Splints Bil.	28	165	M	1 week
9. Jog B	Shin Splints Bil.	35	135	M	10 days
10. Jog C	Shin Splints Bil.	38	140	M	1 week
11. R.G.*	Heel Faciitis Bil.	24	138	M	4 days
12. G.R.*	Chondrolamacia R	18	175	M	2 weeks

CODE:
*TULI'S Heel Cup worn continuously
Jog—jogger
R—right
L—left
Bil.—bilateral

Figure 6.

Statistics—TULI's

RESPONSE			
2 days	**2 weeks**	**2 months**	**extended**
I	C.R.S.	—	—
C.R.S.	—	—	—
C.R.S.	—	—	—
C.R.S.	—	—	—
I	I	C.R.S.	—
I	I	I	Surgical resection
I	I	I	I
P	I	I	I
I	C.R.S.	—	—
I	C.R.S.	—	—
I	I	moved	moved
P	I	I	C.R.S.

RESPONSE:
P—Poor to None
I—Improved condition
C.R.S.—complete remission of symptoms

Some shoe gear today, especially athletic foot gear, has been designed to include shock absorbing qualities. But the placement of these shock absorbing devices has been traditionally on the outside of the shoe. Interior shoe sponge materials are notoriously too hard, or have no repeated long-term memory. TULI's fit inside any shoe, against the foot, where the shock absorption is most needed (Figure 4).

We are not suggesting that the device be used as a substitute for the control of biomechanical faults, namely pronation, but rather that it be employed as an adjunctive or primary therapy. In addition, the TULI's heel cup (Figure 5) may be utilized in conjunction with a custom orthosis.

Figure 6 is a graphic representation of our preliminary clinical trials and results. The majority of our patients in this study were involved in some recreational or competitive sports activity. We feel that two findings in this study are significant:

- All patients had some improvement within the first two weeks of treatment.
- None of the children presenting with calcaneal apophysitis required casting and all returned to complete activity, including those who participated in athletic events.

When considering heel pain, however, one must not preclude systemic disorders as a causative factor. Diabetes mellitus, gout, alcoholism, rheumatic arthritis, and the use of Thiazide diuretics and other drugs have all been implicated.[7] A thorough history and clinical examination is essential in ruling out such entities.

In summary, this paper elucidates the problems of heel strike shock and discusses some of its common clinical manifestations. We have introduced the TULI's dynamic heel cup to be used as an alternate method of aggressive conservative treatment and prophylaxis.

AUTHORS

Dr. Davidson is Director of the Residency Program, Community Hospital of Phoenix. Mr. Quint was a fourth-year student, O.C.P.M., at the time of the writing.

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