The Influence of Early Weight-Bearing Compared with Non-Weight-Bearing After Surgical Repair of the Achilles Tendon

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Background: The optimal rehabilitation protocol after surgical repair of an Achilles tendon rupture has not been well defined. The objective of this randomized study was to compare the effect of early weight-bearing with that of non-weight-bearing on early postoperative recovery following repair of an acutely ruptured Achilles tendon.

Methods: Between October 2003 and May 2006, 110 patients with a surgically repaired Achilles tendon rupture were enrolled from one of two major trauma-care tertiary hospitals. All patients were non-weight-bearing for the first two weeks postoperatively. At the two-week postoperative visit, patients were randomized to either weight-bearing or non-weight-bearing for an additional four weeks. Compliance was measured with a pressure sensor in the fixed-hinge ankle-foot orthosis given to each patient. Follow-up assessments were performed at six weeks, three months, and six months postoperatively. The primary outcome was health-related quality of life assessed with use of the RAND 36-Item Health Survey (RAND-36). Secondary outcomes were activity level, calf strength, ankle range of motion, return to sports and work, and complications.

Results: Ninety-eight patients (89%) completed the six-month follow-up. At six weeks, the weight-bearing group had significantly better scores than the non-weight-bearing group in the RAND-36 domains of physical functioning, social functioning, role-emotional, and vitality scores (p < 0.05). Patients in the weight-bearing group also reported fewer limitations of daily activities at six weeks postoperatively (p < 0.001). At six months, no significant differences between the groups were seen in any outcome, although both groups had poor endurance of the calf musculature. No rerupture occurred in either group.

Conclusions: Early weight-bearing after surgical repair of an acute Achilles tendon rupture improves health-related quality of life in the early postoperative period and has no detrimental effect on recovery.

Level of Evidence: Therapeutic Level I. See Instructions to Authors for a complete description of levels of evidence.
the commencement of weight-bearing, the range of motion allowed, and strength training. This makes it difficult to determine the importance of each factor in the early rehabilitation process for optimizing recovery. Of these measures, early weight-bearing has a great potential to improve patient outcomes or, conversely, negatively impact recovery. One concern with early weight-bearing is the potential disadvantage of increased discomfort and pain while the patient walks on the leg with the healing tendon. This may reduce activity levels and quality of life during this initial phase of recovery. Since an early weight-bearing protocol is applied to the regimen in the first six weeks of rehabilitation, an evaluation of patient health-related quality of life is important in this period. Consequently, the specific factor of early weight-bearing warrants definitive investigation of its influence after Achilles tendon rupture repair.

In the current randomized controlled trial, we hypothesized that early weight-bearing as tolerated following a repair of an Achilles tendon rupture would result in (1) improved health-related quality of life in the initial six-week postoperative period, (2) an overall quicker recovery of health-related quality of life, strength, and endurance, (3) a self-reported earlier return to work and sports, and (4) no increase in complications, including reruptures, compared with a non-weight-bearing protocol. Therefore, the purpose of this study was to determine the effect of weight-bearing as tolerated compared with the effect of non-weight-bearing following the surgical repair of an acute Achilles tendon rupture on health-related quality of life at six weeks postoperatively, functional recovery over the six-month rehabilitation period (as measured by health-related quality of life, strength, and range of motion), return to usual activities and work, and complications.

**Materials and Methods**

**Eligibility and Randomization**

Randomization was performed by computer-generated codes stored in consecutively numbered, sealed opaque envelopes. The study was powered (α = 0.05, β = 0.20) to detect a mean difference between the groups of 10 points (standard deviation of 18 points) in the RAND 36-item health inventory (RAND-36) dimensions. The study was also adequately powered (α = 0.05, β = 0.20) to detect a 10% difference in strength between the groups. With allowance for a 10% attrition rate, 110 patients were required.

Although previous studies have not documented an increased risk of rerupture with an early rehabilitation protocol, a safety rule was put in place to assure patients, clinicians, and the health research ethics board that the safety of our patients was a priority. Rerupture was not a primary outcome, but it was monitored carefully regardless of published evidence. A safety rule established a priori eliminated any dissent among the research team and participating surgeons about stopping the study in the event of an apparent adverse outcome related to early postoperative weight-bearing. If a difference of greater than three spontaneous reruptures occurred between the groups, the intervention would be halted. A spontaneous rerupture was defined as one that occurred without patient instigation of inap-

**TABLE I Inclusion and Exclusion Criteria**

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
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<tbody>
<tr>
<td>Age of 17 to 65 years</td>
<td>Substantial ipsilateral injury</td>
</tr>
<tr>
<td>Functionally complete Achilles tendon rupture</td>
<td>Open injury</td>
</tr>
<tr>
<td>Less than 14 days after injury</td>
<td>Neurological, collagen, or peripheral disease or diabetes</td>
</tr>
<tr>
<td>Isolated Achilles tendon rupture</td>
<td>Pregnancy</td>
</tr>
<tr>
<td>Able to follow rehabilitation protocol</td>
<td>Fluoroquinolone use within two weeks or immunosuppressant therapy within six weeks of injury</td>
</tr>
<tr>
<td>English-speaking</td>
<td>History of Achilles tendonitis or previous ipsilateral rupture</td>
</tr>
<tr>
<td>Consent obtained</td>
<td>Unfit for surgery</td>
</tr>
<tr>
<td></td>
<td>Avulsion from calcaneus</td>
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</tbody>
</table>

The diagnosis of Achilles tendon rupture was confirmed clinically by a palpable gap in the Achilles tendon and a positive Thompson test. For each patient, preoperative prophylactic antibiotics were administered. The surgical repair consisted of posterior longitudinal incisions in the skin and tendon sheath with exposure of the ruptured tendon ends. The tendon was repaired with a variety of suture materials and methods on the basis of the surgeon’s preference (Table II). The incision was closed, and the leg was placed in a posterior splint with the ankle in a relaxed equinus position.

All patients were non-weight-bearing until the first postoperative visit, which was scheduled for two weeks following surgery. At that time, the posterior splint was removed and the patients were managed with a fixed-angle hinged ankle-foot orthosis (Motion Control Walker; DJO, Vista, California), set at the position of rest (approximately 20° of plantar flexion). Patients in both groups were instructed to gradually bring the fixed-angle hinge to 0° of plantar flexion over the first two to three weeks. The patients were given an instruction sheet detailing boot adjustments over two to four-day periods and what symptoms to monitor to ensure they were not making adjustments too rapidly. All patients were taught active dorsiflexion range-
of-motion exercises. Twice daily, patients removed the ankle-foot orthosis and performed these range-of-motion exercises as tolerated.

Following the initial baseline assessment, patients were randomly allocated to either the group managed with weight-bearing as tolerated (fifty-five patients) or the group managed without weight-bearing (fifty-five patients). The patients in the weight-bearing group were encouraged to begin weight-bearing immediately, discarding the crutches once they were comfortable. The non-weight-bearing group remained non-weight-bearing with axillary crutches for four additional weeks. In order to monitor compliance, a sensor was attached to the ankle-foot orthosis in patients in both groups throughout the early rehabilitation period. The sensor was calibrated according to the individual’s body weight and was placed in the heel of the brace. All patients were informed of the purpose for the sensor device.

The patients were reassessed at six weeks, three months, and six months following the surgical repair. At the six-week postoperative visit, all patients were instructed to wean themselves from the use of the ankle-foot orthosis as soon as tolerated. Dorsiflexion, planter flexion, and range-of-motion exercises with resistance tubing; a progressive heel-raise routine; and stationary cycling were added. Exercises were advanced again at the three-month visit to include unilateral heel raises on the affected leg. At the six-month postoperative visit, patients were allowed to resume their regular work and recreational activities.

**Study Measures**

The primary outcome was the six-week postoperative health-related quality-of-life score with use of the RAND-36, a validated health-related quality-of-life questionnaire. The RAND-36, which contains identical items to the Short Form-36 (SF-36) questionnaire and has been validated for use with multiple patient groups, measures eight domains of health: physical functioning, physical role, bodily pain, general health, vitality, social functioning, emotional role, and mental health. The RAND-36 was chosen over the SF-36 because of its availability in the public domain without cost.

Secondarily, both preinjury and postoperative measures were recorded. The preinjury measures included patient-reported type of work and activity (sedentary, light, or heavy). Postoperative data that were recorded included comparison of recovery over the six-month rehabilitation period (as defined by health-related quality of life, range of motion, and strength), six-month endurance, and complications at each follow-up visit. In addition, comparison of the return-to-work date and duties (modified or nonrestricted) and the postoperative activity level was noted. An additional item from the ankle-hindfoot scale addressing activity limitations and support requirements on a 4-point scale was included in the questionnaire.

At the six-week, three-month, and six-month follow-up visits, the patients were assessed by experienced physiotherapists, blinded to group allocation, who measured ankle range of motion with a goniometer with use of published standards. Isometric plantar flexion and dorsiflexion strength were assessed with use of a handheld myometer. Calf circumference was assessed with a measuring tape placed 10 cm distal to the patellar apex of the fully extended knee. Single-leg heel raises were performed with use of a customized counting device in

**TABLE II Suture Type and Method**

<table>
<thead>
<tr>
<th>Suture type</th>
<th>Weight-Bearing as Tolerated Group (No. of Patients)</th>
<th>Non-Weight-Bearing Group (No. of Patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.-2 Ethibond</td>
<td>26</td>
<td>25</td>
</tr>
<tr>
<td>No.-5 Ethibond</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>No.-2 Dexon</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No.-1 Vicryl</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>No.-2 Vicryl</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

**Suture method**

1. Kessler
2. Modified Kessler
3. Bunnell
4. Other
5. Unknown

*Ethibond and Vicryl sutures are manufactured by Ethicon, Somerville, New Jersey, and Dexon sutures, by Davis and Geck, Sugarland, Texas.

**TABLE III Baseline Comparison of Patient Characteristics**

<table>
<thead>
<tr>
<th>Baseline Variable</th>
<th>Weight-Bearing as Tolerated Group (N = 55)</th>
<th>Non-Weight-Bearing Group (N = 55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>40.6 (9.5)</td>
<td>38.1 (9.0)</td>
</tr>
<tr>
<td>Male patients</td>
<td>47 (86%)</td>
<td>46 (84%)</td>
</tr>
<tr>
<td>Body mass index*</td>
<td>28.5 (7.6)</td>
<td>27.1 (3.1)</td>
</tr>
<tr>
<td>Right side involved</td>
<td>24 (44%)</td>
<td>24 (44%)</td>
</tr>
<tr>
<td>Job reported as heavy</td>
<td>14 (25%)</td>
<td>11 (20%)</td>
</tr>
<tr>
<td>Sports and/or activity reported as heavy</td>
<td>21 (38%)</td>
<td>22 (40%)</td>
</tr>
<tr>
<td>RAND-36 score*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical functioning</td>
<td>94.1 (19.5)</td>
<td>94.4 (17.6)</td>
</tr>
<tr>
<td>Role-physical</td>
<td>92.6 (22.1)</td>
<td>92.6 (24.1)</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>91.3 (13.7)</td>
<td>90.1 (17.8)</td>
</tr>
<tr>
<td>General health</td>
<td>88.5 (15.5)</td>
<td>91.1 (12.4)</td>
</tr>
<tr>
<td>Vitality</td>
<td>81.2 (20.2)</td>
<td>84.1 (11.9)</td>
</tr>
<tr>
<td>Social functioning</td>
<td>98.6 (5.2)</td>
<td>96.8 (11.2)</td>
</tr>
<tr>
<td>Role-emotional</td>
<td>98.8 (9.1)</td>
<td>96.9 (14.9)</td>
</tr>
<tr>
<td>Mental health</td>
<td>90.6 (10.0)</td>
<td>90.7 (10.9)</td>
</tr>
</tbody>
</table>

*The values are given as the mean, with the standard deviation in parentheses.
In order to measure endurance at the six-month follow-up, a successful heel raise was determined by the breaking of a laser beam by the affected heel. The level of the laser beam was determined by the height attained with a single-leg heel raise on the noninjured side. Patients performed unilateral heel raises until they were no longer able to attain the height required to break the laser beam. Range of motion, isometric strength, calf circumference, and endurance measurements were analyzed as a proportion of that of the noninjured side.

Assessment of complications occurred at all visits. Complications were defined a priori as major or minor. Complications requiring additional surgery, readmission to the hospital, or prolonged medication were considered major (e.g., rerupture, deep infection, deep venous thrombosis, pulmonary embolism,
and wound slough), while any other complication was classified as minor (e.g., superficial infection, sural nerve dysesthesia, delayed wound-healing, and scar adhesion).

**Statistical Analysis**

The chi-square test was used for categorical or nonparametric data, and the Student t test was used for continuous parametric data. The primary outcome was the health-related quality of life at six weeks, which was measured with use of an independent t test. Two-way repeated-measures analysis of variance was used to compare recovery over time between groups in terms of health-related quality of life, range of motion, and strength. The level of significance was set at $\alpha = 0.05$ for all tests. The data analysis strategy included both an intention-to-treat and a per-protocol analysis (sensitivity analysis). In the intention-to-treat analysis, data on the patients were analyzed according to the groups to which the patients were initially randomly allocated despite compliance violations. This reflects typical clinical practice. Conversely, in the per-protocol analysis, compliance was taken into account and data were analyzed on the basis of the intervention that the patients actually received in the study. The per-protocol analysis allowed for determination of the effect of noncompliance on the findings.

**Results**

Baseline characteristics appeared similar between groups (Table III). The mean time from injury to surgery was approximately three days in both groups. Most injuries leading to the Achilles tendon rupture were related to sports (93%), most commonly racquet sports and soccer.

Ninety-eight (89%) of 110 patients completed the six months of follow-up (Fig. 1). The timing of postoperative visits was similar between groups. All patients remained in their allocated treatment group. The total median number of steps between the two-week and the six-week visit was 5985 steps (interquartile range, 278 to 17,747 steps) for the weight-bearing group and 960 steps (interquartile range, 1 to 5303 steps) for the non-weight-bearing group ($p = 0.01$). Comparison of the per-protocol analysis with the intention-to-treat analysis revealed no differences in the reported results. That is, removing noncompliant patients from the weight-bearing group and placing them in the non-weight-bearing group (and vice versa) had no effect on the pattern of results. Therefore, only the intention-to-treat results are presented.

At the six-week follow-up visit, the group managed with weight-bearing as tolerated reported significantly better outcomes in the domains of physical functioning, vitality, social functioning, and role-emotional (Table IV). Furthermore, twenty-three patients (43%) in the weight-bearing group and five patients (9%) in the non-weight-bearing group reported either no limitations or limitations only in recreation at the six-week follow-up visit ($p < 0.001$).

The two-way repeated-measures analysis of variance comparison of the RAND-36 questionnaire revealed that only social functioning differed between groups over time ($p < 0.001$). The weight-bearing group had significantly better social functioning than the non-weight-bearing group during the overall recovery period ($p = 0.04$, Fig. 2). No difference was observed between the groups in any of the physical assessment parameters, with all patients showing substantial recovery over time.

At the six-month follow-up, the calculated calf endurance of both groups was approximately 50% of that of the unaffected side, with no difference noted between the groups. Approximately 65% of the patients had returned to work by six weeks; 82%, by three months; and 97%, by six months. At six months, 67% of the patients managed with weight-bearing as tolerated and 63% of those managed with non-weight-bearing returned to at least partial sports activity. Return to work and sports and other outcomes, such as reports of pain, stiffness, and numbness in the Achilles tendon area, did not appear to differ between groups at any follow-up visit.

Complications did not appear to be different between groups, and no rerupture occurred in either group. Major complications occurred only in the non-weight-bearing group, with one patient (2%) who had a deep venous thrombosis develop and one patient (2%) who sustained a wound slough. Eight (15%) of the patients managed with weight-bearing as tolerated and nine (16%) of the patients managed with non-weight-bearing had minor complications. These included sural nerve dysesthesias, superficial infections, delayed wound-healing, and scar adhesions. All of the minor complications had resolved or improved by six months.
Discussion

This randomized controlled trial demonstrated a clear patient benefit for weight-bearing as tolerated compared with non-weight-bearing following surgical repair of a ruptured Achilles tendon in the initial six-week postoperative period, with better outcome scores in multiple domains of the RAND-36, as well as fewer limitations with daily activities. No other group differences were found. Six months postoperatively, patients in both groups reported few limitations in activities including work and sports. It should be noted that the return to work and sports outcomes can be influenced by many extraneous factors that were not assessed in this study, and thus these outcomes should be interpreted with caution.

Protocols in case-control series for early functional rehabilitation after surgical repair of an Achilles tendon rupture arose as early as 1974. Five randomized controlled trials comparing an early functional rehabilitation protocol with an immobilization protocol have been published to date. All studies found that early mobilization improved at least one aspect of recovery, such as an earlier return to normal walking and stair-climbing, work, or sports; improved plantar flexion strength; greater range of motion; or reduced calf atrophy. No study noted any major detrimental effects of the early mobilization protocols. A critical comparison among these studies is difficult because of treatment protocol heterogeneity. Our study isolated weight-bearing as tolerated as the sole intervention. The results of this study conclusively demonstrated the beneficial effects of the early weight-bearing protocol on early postoperative health-related quality of life without detrimental effects.

We anticipated that the group managed with weight-bearing as tolerated would demonstrate an earlier recovery of strength similar to previous studies, but our results did not support this hypothesis. Strength recovery was similar between the groups at all follow-up periods. The fixed-angle hinged ankle-foot orthosis may have prevented the toe-off phase of the gait cycle, accounting for this result.

Another unexpected finding was the heel-raise endurance impairment of 50% for both groups at six months, although strength measured in a non-weight-bearing position was >90% of that of the uninjured side. Traditionally, after an Achilles tendon repair, patients are informed that they can resume normal activities at six months. Poor endurance at this time suggests that additional rehabilitation is required, especially for active patients. Persistent deficits in muscle strength and endurance have been reported in other studies and have been noted to last as long as six years postoperatively.

Our study is the first that we know of to quantify compliance with weight-bearing after an Achilles tendon repair. Patients were informed of the purpose of the sensor device, which prob-

![Comparison of mean social functioning scores on the RAND-36 between weight-bearing as tolerated (WBAT) and non-weight-bearing (NWB) groups, over each measurement period (baseline, six weeks, three months, and six months). This graph depicts the two-way repeated-measures analysis of variance.](image-url)
ably facilitated compliance to the assigned weight-bearing protocol. The degree of compliance monitoring used in this study is not feasible in clinical practice. Given the similarity in the findings of the intention-to-treat and per-protocol analyses, similar results regarding compliance can be expected in clinical practice.

We believe that this is the largest randomized study to date to examine the postoperative rehabilitation of Achilles tendon ruptures. The generalizability of this study, however, may be limited to those patients meeting the specified criteria (Table I). The demographic data on the patients and the time to surgical repair were comparable with those reported both in the literature and clinical practice, suggesting that our results are applicable to most candidates who are eligible for surgical repair and are able to adhere to the rehabilitation protocol. It should also be noted that, by chance, absorbable sutures were used only in the non-weight-bearing group and therefore our reported early weight-bearing outcomes may not be generalizable to patients in whom the rupture was repaired with absorbable sutures.

Unfortunately, a recently published, validated outcome measure specific to Achilles tendon ruptures was not available at the time of study commencement. Additional group differences may have been detected if we had used a more responsive disease-specific questionnaire.

It is uncertain whether the introduction of a protocol of weight-bearing as tolerated has implications with regard to postoperative deep venous thrombosis. Although anticoagulation therapy is recommended in patients who are at risk for prolonged immobilization, our study did not use anticoagulation medications in the protocol. The solitary instance of deep venous thrombosis that occurred in the study was in a patient in the non-weight-bearing group, and early weight-bearing may have had a protective effect through muscular contraction to prevent the formation of deep venous thrombosis. However, as this study was not powered to measure differences in thrombotic events without anticoagulation, no definitive conclusions can be made.

The postoperative early weight-bearing protocol provided enhanced quality of life and activity level without an increase in complications in the early postoperative period. Given these findings, this protocol has been adopted as the new standard of care in our tertiary health-care region for appropriately selected patients.

References