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A Complete Achilles Tendon Rupture-- An Anatomical Review and Case Study of the Treatment, Surgery, and Rehabilitation of One Complete Rupture

Myron J. Cullen

A COMPLETE ACHILLES TENDON RUPTURE--
AN ANATOMICAL REVIEW AND CASE STUDY
OF THE TREATMENT, SURGERY, AND
REHABILITATION OF ONE COMPLETE RUPTURE

by
Myron J. Cullen

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This Thesis submitted by Myron J. Cullen in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

W. C. Koenig
(Chairman)

Helen Smiley

Thomas B. Scott

This Thesis meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

A. William Johnson
Dean of the Graduate School

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Title A Complete Achilles Tendon Rupture--An Anatomical Review and Case Study of the Treatment, Surgery, and Rehabilitation of One Complete Rupture

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Signature Myron Cullen

Date 4/17/81

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A number of people have helped a great deal with this study. I would first like to thank Mr. Jim Rood who graciously allowed me to make a study of his injury. Doctor John Beaumier was very helpful in allowing me to create and carry out this rehabilitation program. His trust in allowing me to work with Mr. Rood was appreciated.

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ABSTRACT

The purpose of this thesis was to study the anatomical structure, mechanical function, and mechanism of injury of the Achilles tendon. The surgical procedure, description and results of the rehabilitation program, developed by this researcher specifically for this injury, were presented.

A case study of one twenty-three-year-old male subject was the basis of this study. A day-by-day follow-up of the subject's rehabilitation program from surgery to dismissal from rehabilitation were presented.

The results of this rehabilitation program were favorable. This subject was able to return to daily activities much sooner than expected and was able to participate in a competitive activity only six months after surgery.

The program cannot be generalized as useful to the population. It was designed for a particular subject who was able to spend two hours a day in therapy. The rehabilitation program can be used as a guideline for future programs for complete Achilles tendon ruptures.

CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

Introduction

There has been a great surge of interest in sports during the past few years, as evidenced by the increased participation in such activities as jogging, skiing, softball, and tennis. As the number of participants in amateur sport increases, so does the number of sport-related injuries. One injury which has shown an increase in occurrence is the complete rupture of the Achilles tendon (1).

The purpose of this thesis was to study the anatomical structure, mechanical function, and mechanism of injury of the Achilles tendon. The surgical procedure and the description and results of the rehabilitation program, developed by this researcher specifically for this injury, were presented.

This case study was done on one male subject. The surgery used was one of many which could have been used. The fact that it was chosen for this particular subject does not imply that it was a better surgery to use, but simply that the surgeon preferred this technique. The success or failure of this developed rehabilitation program was based on one subject, thus the findings should not be generalized for the entire population.

Review of the Literature

Anatomy

The Achilles tendon is the common tendon of the gastrocnemius and soleus (triceps surae) (2-9). It is the thickest and strongest tendon in the body with an experimental tensile strength of 18,000 pounds per square inch (3,7,9). It is usually flexible, but does lack in great amounts of elasticity (2). The length of the tendon is approximately six inches. It commences about the middle of the leg and receives fleshy fibers on its anterior surface nearly to its insertion. At the tendon's insertion it spreads out somewhat, creating the tendon's narrowest part about an inch and a half proximal to its insertion. The Achilles tendon inserts onto the lower part of the posterior surface of the calcaneous, where a synovial bursa (the retrocalcaneal) is interposed between the tendon and the upper part of the calcaneal surface (7).

The Achilles tendon, like any other tendon, is comprised of three main proteins: elastin, reticulin, and collagen (2).

The tendon is a highly dense fibrous band which is made up of individual tendon fibers (2). The riber arrangement of the Achilles tendon differs from the fiber arrangement of other tendons. The latter are usually arranged in a uniform and longitudinal fashion. The Achilles tendon fibers undergo a spiral twist in their course from the muscular origin to their insertion into the calcaneous (2, 3). Spiral configuration permits combined movements of the ankle and subtalar joint without undue tensions being placed upon individual fibers of the tendon or without requiring any internal slippage between the fibers within the tendon (3). The fibers on the posterior side of the Achilles tendon run from the medial side toward the lateral side of the calcaneous. The fibers comprising the anterior surface of the Achilles tendon run in a reverse direction (3). All fibers, whether spiral or longitudinal, are grouped together in bundles which are held together by endotenon tissue(2).

The Achilles tendon, like any other living tissue, needs the proper nutrients to maintain itself (4). In the early 1900's it was established that tendons do have a system of circulatory vessels (5). Tendon vascularization has been shown to originate at one of three locations: (1) musculotendinous junctions; (2) tendinoperiosteal insertion; or (3) longitudinal surface of mesentery (6). It recently has been shown that vascularization is most abundant at each end of the tendon (5). Lagergren, et al. have shown that the middle third of the tendon has the poorest circulation, and the highest injury rate (5, 9).

There are usually three types of sensory receptors found in tendon tissue. Golgi tendon organisms are found in the musculotendinous junction and serve as proprioceptors. Pacinian corpuscles are usually found in tendon sheaths and are also proprioceptors, as well as being pressure receptors. Noriceptors (free nerve endings) are also found in the tendon sheaths and are mainly pain receptors (4).

Most tendons are surrounded by a synovial sheath which creates a fluid to aid in the gliding action of the tendon. The Achilles tendon, however, is surrounded by a peritendon sheath which means that the tendon relies on fluid for lubrication in and about the peritendon tissue. This fact makes tenosynovitis of the Achilles tendon impossible due to the fact that tenosynovitis is an inflammation of the synovial sheath (4). The Achilles tendon is also covered by the fascia and the integument and is separated from deep muscles and vessels by a considerable interval filled up with areolar and adipose tissue (7).

Function

The functional purpose of the tendon is to create an efficient system of motion by connecting muscle tissue to bone. As the muscle contracts, tension is built upon the tendon. The tendon transfers the tension to the bone at the insertion point. This creates a third degree lever system which generates movement of the part with minimal effort (4).

As the gastrocnemius and soleus contract, tension is placed upon the Achilles tendon. Tension placed upon the Achilles tendon causes plantar flexion and inversion of the foot (3, 4). It should be noted here that the soleus is the primary contributor of strength during plantarflexion (8, 9). Literature states that the combination of the gastrocnemius and soleus muscle may account for anywhere between 87 percent to 95 percent of the plantarflexion action (2, 10, 11). The remaining percentage comes from the assistance of other muscles of the posterior side of the leg.

Mechanism of Injury

Achilles tendon ruptures are most common in the middle-aged, 30-50-year-old, recreational athlete, but can occur at any age (11, 12, 13). It is also more common to the male than to the female (14). Experimentally it has been shown that a completely healthy tendon does not rupture even under the heaviest stress (10, 12). This thought, combined with the tensile strength of 18,000 pounds per square inch, leaves one in a dilemma; if these last two statements are true, what causes the

Achilles tendon to rupture? Many authors have accredited the Achilles tendon rupture to local degenerative changes and trauma from excessive stress and contusions. Other factors leading to rupture are recurrent microtrauma, diffuse fibrosis, longitudinal clefts from fiber dissociation, ruptured fibers, and chronic inflammation (9, 13, 15).

The location of the rupture is dependent upon the condition of the tendon structure. If the tendon is healthy, one can suspect the rupture to occur either in the muscle itself, the musculotendinous junction, or at the insertion of the tendon (an avulsion fracture) rather than in the tendon itself (4, 16, 17).

If the Achilles tendon were in degenerative changes, the rupture could occur in the tendon itself. There are several locations of possible rupture. The most common rupture site is the area of decreased vascularity, 2 to 6 cm proximal to the tendinous insertion in the calcaneous (9). This area corresponds nicely with the findings of Lagergren, et al. (4). Shields, et al. showed these varying levels of tendon ruptures (18).

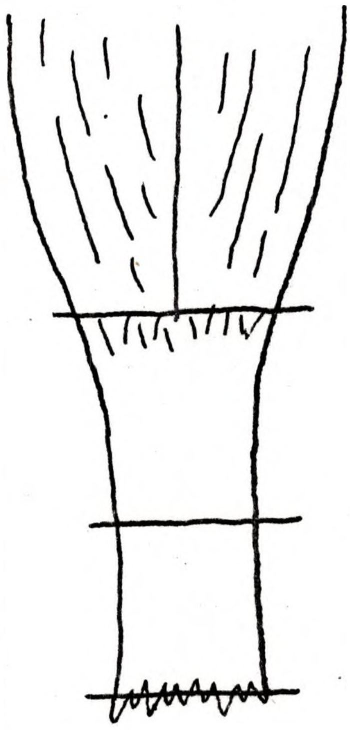


Fig. 1. Possible levels of tendon rupture.

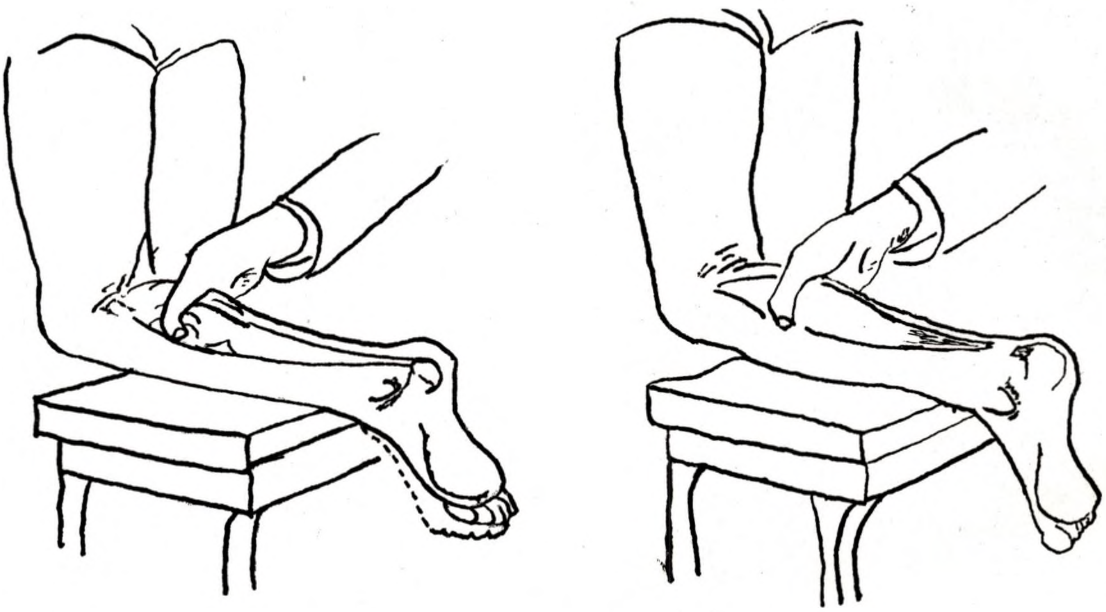
Before a total rupture of the Achilles tendon occurs, there are several symptoms which usually occur. These symptoms are: (1) discomfort described as dull, stabbing, or pricking sensation; or (2) pain on weight bearing in the affected area (16).

Rupture is possible in any sport which requires a stop-and-go type of action (13). The Achilles tendon (which is attached to the biarticular triceps surae) is subjected to the accumulated forces of knee extension and foot plantarflexion. In addition to these forces the elastic coefficient of a muscle decreases with contracting and shortening, which helps to explain the most occurring mechanism of Achilles tendon rupture (10, 19). The mechanism is a sudden pushoff action of the forefoot with the knee being forced into full extension (13, 18). The other two mechanisms of injury are described as a sudden, unexpected dorsiflexion of the foot and forced dorsiflexion of a plantarflexed foot (18).

The symptoms of a ruptured Achilles tendon are rather obvious. These symptoms are: audible snap or pop, much like a rifle shot which may be heard by a spectator; sudden pain, like being kicked in the heel or that something had just burst; a loss of strength and power in plantarflexion; loss of function, which may cause one to fall, which is more likely due to muscle spasm and pain rather than the loss of continuity of the tendon; an obvious indentation in the tendon; shortly after the rupture there will be a great amount of swelling and maybe some discoloration in the area of the tendon, and finally muscle action will bunch up rather than flatten down (11, 13, 16, 17, 18, 19, 20). Even though a person may have a total rupture, the pain may be so mild that medical attention is not sought immediately (11). The injured person may still have active plantarflexion due to the action of the tibialis posterior and flexor peroneal muscles on the posterior aspect of the leg which may lead to the misdiagnosis of tennis leg, traumatic hematoma, avulsion fracture of the calcaneous, tendonitis, or bursitis (16, 21).

Evaluation and Care

To correctly evaluate an Achilles tendon rupture the Thompson test should be used. It has been found to be the most reliable of all tests in diagnosis of complete Achilles tendon ruptures (1, 13, 18, 22). To perform the Thompson test, have the patient lie prone on the examination table, and squeeze the calf of the leg. If the Achilles tendon is ruptured, plantarflexion is decreased or absent (23, 24).



Figs. 2 and 3. Thompson test

Along with the Thompson test for Achilles tendon rupture evaluation, there are several radiological signs which are specific to this injury. First is the radiological triangle of Kager. This triangle is mostly fatty tissue enclosed anteriorly by the posterior surface of the flexor tendons of the foot on the dorsal side of the tibia, posteriorly by the anterior aspect of the Achilles tendon, and distally by the proximal surface of the calcaneous. When the Achilles tendon ruptures, the triangle of Kager is destroyed, as soft tissue moves dorsally forming the angle of Toygar. There are three other radiographic signs specific to ruptured Achilles tendon: (1) obscuration of the tendon; (2) posterior encroachment of the fat pad; (3) soft tissue mass at the tendon ends (24, 25, 26). X-rays should also be taken to rule out a fracture of the medial malleolus of the ankle which occasionally accompanies ruptures of the Achilles tendon (21).

The best care of Achilles tendon ruptures is still an unanswered question for many. The most current literature favors surgery over conservative treatment (9). Surgery shows the best results when the rupture is repaired immediately (18). Most surgeries are done on the medial side to prevent altered sural nerve involvement during rehabilitation (27). The following complications are possible with surgical care: (1) skin sloughs; (2) scar adhesions; (3) thrombosis; (4) wound infection; (5) skin necrosis; (6) sensory loss; (7) draining fistula; (8) swelling; (9) thickening of the tendon; (10) weakness; (11) atrophy of muscles; (12) decrease in dorsiflexion and plantarflexion; (13) and a limp (19, 29, 30, 31).

The benefits of surgery are: (1) a fast return to activity; (2) ability to have a fast return of powerful plantarflexion; (3) fast return of power, strength, and endurance of plantarflexors; (4) good return of full range of motion; (5) and less chance of re-rupture as compared to conservative methods (2, 9, 29).

CHAPTER II

CASE STUDY

The following is a case study of one twenty-three-year-old male, amateur athlete who sustained a complete rupture of his left Achilles tendon during a softball game. The study began approximately fifteen hours after the injury occurred.

History

The subject entered the training room with what might be referred to as a "peg-leg gait." The weight of each stride was placed on the heel of the injured leg and regular gait plantarflexion and dorsiflexion were eliminated. There was marked swelling of the Achilles tendon, with the greatest amount of hematoma approximately two inches above the tendinous insertion on the calcaneous. Before further physical evaluations were completed, a complete history of the mechanism of injury was taken.

There had been a degree of unusual soreness in both calves during the day, prior to an evening softball game. Knowing that the soreness was not normal, an extensive pre-game warm-up was completed by the subject. The warm-up consisted of fifteen situps and pushups, ten toe-raisers, twenty minutes of thigh and calf stretching, and a half mile jog. Between the first four innings, massage was applied to the calves whenever possible.

While at bat in the fifth inning, the subject sustained a severe cramp in the left triceps surae. As this occurred the subject struck the softball and began to explosively sprint towards first base. On the third stride of the sprint, a loud sound, much like a rifle shot, was heard by the subject and nearby spectators. A snap was felt by the subject at the same time the sound was heard. An immediate loss of function occurred, resulting in the subject's falling to the ground. There was little pain, thus the subject was able to stand up and use the peg-leg gait to get to a nearby bench.

The following morning the subject came to this researcher for evaluation.

From the visual observation and the history, it was somewhat obvious what injury had occurred. But to rule out any doubt, the Thompson test was performed. The Thompson test was positive so the subject was referred to Dr. John Beaumier for a diagnosis. Dr. Beaumier diagnosed the injury as a complete rupture of the Achilles tendon and elected to correct the rupture with surgery.

Surgery

As stated before, this surgery is one of many which could have been used. Its use here is not implying that it is the best surgery to use for this condition, nor is it being said that a better surgery could have been used. It is simply the surgery which Dr. Beaumier elected to use on this patient.

(Refer to the Appendices for the surgical report.)

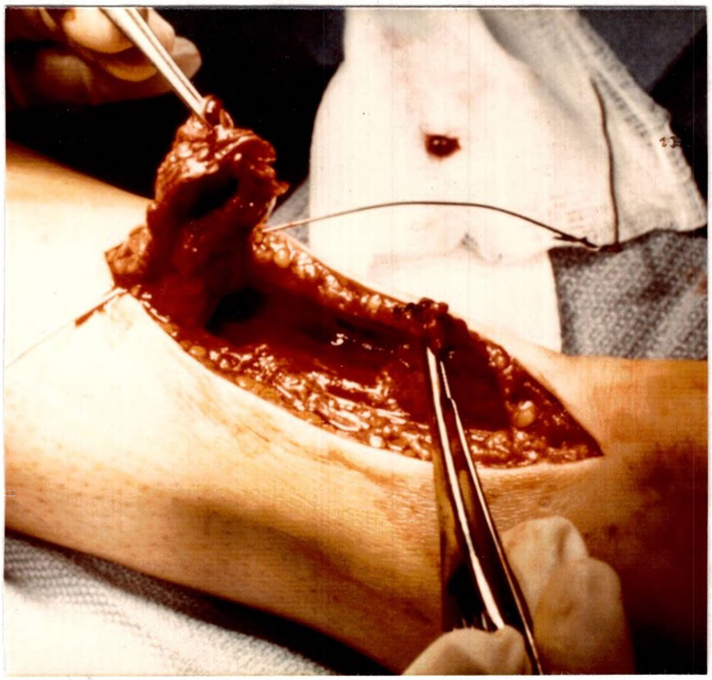


Fig. 4. Surgical view of rupture and pull-out wire

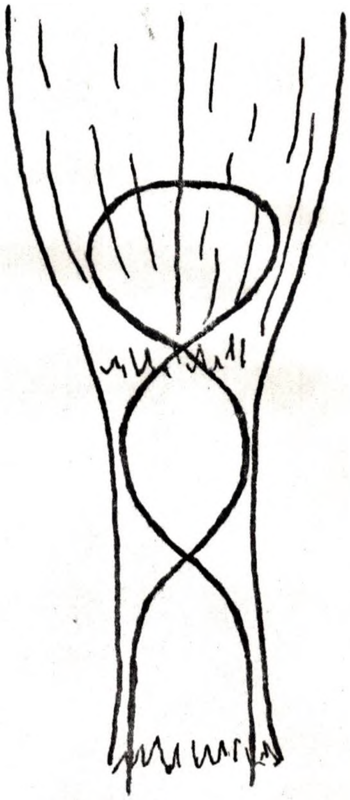


Fig. 5. Placement of pull-out wire

Fig. 6. Exit holes of pull-out wire

Rehabilitation

The following is the basic rehabilitation program developed by this researcher for this particular subject. The specifics of the program will be discussed later.

Rehabilitation Phases

I. Maximum Protection Phase (0-6th week)

A. Full leg cast

1. Absolute blocking of knee and ankle movement

B. Sitting Straight Leg Raisers

1. Maintain musculature of quadriceps, hamstrings, abductors, and adductors

II. Minimum Protection Phase (7-10th week)

A. Short leg cast applied

1. Full leg cast and pull-out wire removed which then allows knee movement, but maintains absolute ankle movement blockage.

B. Crutch Weaning

1. Full use first two weeks

2. Go to gradual weight bearing last two weeks

C. Orthotron

1. Continue maintenance of musculature strength and endurance of thigh muscles

D. Electrical Stimulation

1. Help maintain musculature and aid in nerve stimulation and muscle relaxation

III. Walking Phase (11-17th week)

A. Short leg cast removed

1. Must achieve full range of motion, strength, and endurance of leg muscles

B. Crutch Weaning (11-12th week)

C. Modalities

1. Electrical Stimulation

2. Ultra Sound

3. Massage

4. Stretching (Gradual)

5. Pool and Ice Whirlpool

D. Orthotron*

1. For thigh musculature development and leg muscle and ankle joint stretching

IV. Full Weight Bearing Walking Phase (12-17th week)

A. Continue Modalities and Orthotron

1. Add stair workout

V. Advanced Rehabilitation Phase (13-17th week)

A. Continue Modalities and Orthotron

1. Add coordination and gait training

2. Dismissal (18th week)

This rehabilitation program was approved by Dr. Beaumier.

*Orthotron workout for the thigh musculature is dropped from the program when both thighs have equal strength.

Specifics of Rehabilitation Program

Maximum Protection Phase

As stated earlier, the triceps surae is a biarticular muscle. It serves as an ankle plantarflexor and knee flexor.

In order to maintain absolute blockage of triceps surae muscle movement, both the knee and ankle must be immobilized in a full leg cast.

In full extension of the knee, the gastrocnemius is tight (23). The tightness of the gastrocnemius in extension may place too much pressure on the sutures holding the tendon together (31). In order to place the gastronemius in a relaxed position and to relieve pressure on the sutures, the knee must be partially flexed. For that reason, the full leg cast is placed in thirty degrees of knee flexion.

The ankle joint is placed in as much dorsiflexion as possible. Dorsiflexion is advantageous as constant tension of the muscle enhances nerve stimulation (30). Even though an attempt is made to force the ankle into dorsiflexion, it remains in a plantarflexed position. Constant tension is desired, but again it must not be too great for the sutures. Thirty degrees of plantarflexion gives enough tension but allows the tissue to heal properly (31).

Fig. 7. Full leg cast demonstrating 30° of knee flexion.

During the period of casting, there was a marked decrease in the circumference of the leg due to atrophy of the musculature (1, 28). Murray, et al. stated that cross sectional area reduction is related to the force the muscle can produce, thus casting would create a substantial reduction of strength of muscle (30). This decrease in maximal force a muscle can produce, hypotrophy, is a good indicator that structural deterioration is occurring (28).

It is of importance then to create an exercise program which will prevent atrophy and thus hypotrophy of the thigh musculature. The leg musculature will have to be neglected to allow proper healing to occur within the Achilles tendon. Straight leg raisers were used to prevent atrophy of the thigh musculature.

In order to increase strength in muscle tissue, the muscle must be overloaded (32). In order to overload the muscles of the thigh, the thigh musculature must do the majority of the work. If supine straight leg raisers are used, prime movers of the hip will assist the quadriceps during the leg raising action. The hip flexors must be eliminated as much as possible. In order to do this, the subject should be sitting; this position will decrease the function of the hip flexors and place more work on the quadriceps.

Fig. 8. Sitting straight leg raisers (Model is not subject of this study)

Fig. 9. Straight leg raisers (Model is not subject of this study)

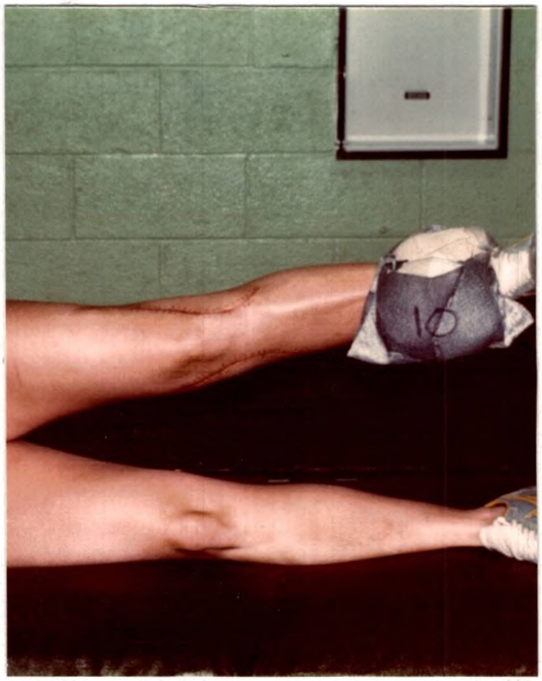


Fig. 10. Straight leg raisers (Model is not subject of this study)

Fig. 11. Straight leg raisers (Model is not subject of this study)

Figures 9, 10, 11 show how the remaining movements of extension, abduction and adduction are performed.

The following table states the repetition and procedure used for these leg raisers.

TABLE 1

STRAIGHT LEG RAISER PROGRAM FOR FLEXION, EXTENSION, ABDUCTION, AND ADDUCTION INCLUDING STRENGTH AND ENDURANCE PROCEDURES

Movement	Duration and Repetition	Procedure
Flexion (strength)	6 sec. 3 sets of 10	Tighten prime movers, left leg six inches, hold duration, lower leg to table, relax quadriceps.
Flexion (endurance)	1 set of 20 fast	Same procedure as above, but eliminate six second hold
Extension (strength)	6 sec.	Same as flexion for strength
Extension (endurance)	1 set of 20 fast	Same as flexion for endurance
Abduction (strength)	6 sec. 3 sets of 10	Same procedure for strength
Abduction (endurance)	1 set of 20 fast	Same procedure for endurance
Adduction (strength)	6 sec. 3 sets of 10	Same procedure for strength
Adduction (endurance)	1 set of 20 fast	Same procedure for endurance

Sand bag weights can be placed on the casted leg for extra resistance during the leg raisers.

A window could have been placed in the cast to allow electrical stimulation of the thigh musculature, but due to the use of the metal pull-out wire, the use of this modality was impossible.

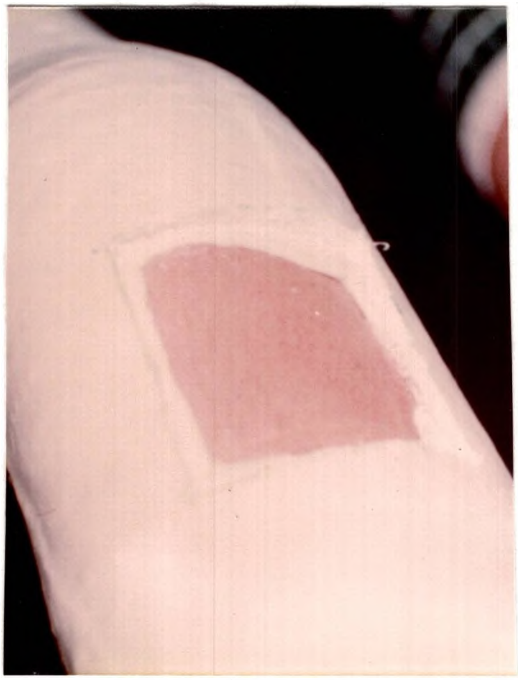


Fig. 12. Windowed cast

Fig. 13. Electrical stimulation pad in window of cast

Minimum Protection Phase

This phase is initiated with the removal of the full leg cast and metal pull-out wire and the placement of a short leg cast. The short leg cast allowed for full range of motion in the knee joint. Straight leg raisers were replaced then with an Orthotron program to maintain the muscle strength and endurance of the thigh musculature. The Orthotron program is shown in Table 2.

Electrical stimulation is also added to the rehabilitation program to enhance muscle tone, nerve stimulation, and muscle relaxation.

Walking Phase

Removal of the short leg cast begins this phase of the rehabilitation program. In addition to the continuing work on the thigh musculature, it is now necessary to develop a program for the leg musculature and ankle joint. The ankle joint is moved by the tendons of the leg musculature, so rehabilitation done on the leg benefits the ankle. The areas of concern are full range of motion of the ankle joint, reduction of scar build-up, and strength and endurance of the leg musculature.

Electrical stimulation was used to enhance nerve stimulation and, through its mechanical action, break up scar tissue around the surgical site leading to a greater range of motion. Ultrasound was used to break up scar tissue and increase blood flow.

Daily massage was given to enhance blood flow and break up scar tissue. It also gave the subject a relaxed sensation.

The subject also had a pool workout. This was beneficial because it allowed the ankle to go through full weight bearing and range of motion without discomfort.

TABLE 2

ORTHOTRON PROGRAM--DAILY AND WEEKLY PROCEDURE

Days		Setting[a]	Reps		Setting[a]	Reps
Monday		3	3 sets of 10		7	1 set of 20
Wednesday	1)[b]	5	3 sets of 10	then		
Friday		7	3 sets of 10			
		3	5 sets of 10			
then	2)[6]	5	5 sets of 10	then	7	1 set of 20
		7	5 sets of 10			

Tuesday
Thursday The top half of Monday, Wednesday, Friday workout.

[a]Setting-number is a standard setting on Orthrotron dials. The lower the number, the more resistance.

[b]Subject should complete row 1, then row 2.

The water created a bouyant effect on the subject, reducing the pressure on the repaired Achilles tendon. The first workouts consisted of walking. As this phase progressed, running and stair climbing were incorporated into the workouts. All pool workouts continued until fatigue developed.

A system of gradual stretching was added to the rehabilitatin program. Stretching was carried out in the pool for the first two weeks; it was then completed on dry ground. (Refer to the Appendices for the stretching program (33).)

During the first few weeks of this phase, the Orthotron was used for passive stretching. Only after the subject was able to reach 0° of dorsiflexion was the Orthrotrol used for strength and endurance development of the leg musculature. The previously mentioned Orthotron program was used for the leg musculature.

Each day the subject would receive a massage, then electrical stimulation and ultrasound, then the pool workoug, and finally the Orthotron workout. After this strenuous routine, the surgical site was immersed in an ice whirlpool to help in prevention of swelling. Then a neophyme sleeve was applied to maintain a constant pressure. It should be noted here that ultrasound was used eleven days in a row and then discontinued as suggested by a physical therapist.

Full Weight Bearing

The beginning of this phase was announced by the discontinued use of crutches. The previous program was continued with the addition of a stair workout. The subject walked up and down a staircase in a backward fashion. This was done to help create coordination, strength, and flexibility.

Advanced Rehabilitation

Continued use of the previous program was added to coordination and gait training. The subject was instructed to complete several repetitions of coordination skills. These skills included such activities as toe-raisers, picking up marbles with the toes, rolling up a towel with the toes, and running skills such as cariocas and figure eights.

Gait training consisted of proper foot placement to prevent a pigeon-toed gait. Such skills as walking heel-toe and toe-heel in a reversed direction were used.

Dismissal

At the end of the eighteenth week, the subject was released by Dr. Beaumier. It was the decision of the subject to then discontinue treatment. The subject was able to work and carry out daily tasks without difficulty.

Three months later, the subject participated in a winter softball tournament without difficulty.

CHAPTER III

DISCUSSION AND CONCLUSION

This rehabilitation program appeared to give excellent results on the surface, but a few unanswered questions remain. During the first few weeks of the walking phase, a peculiarity was noted. During any stage of plantarflexion, there was an involuntary flexion of the toes.

No matter which exercise was attempted, this condition could not be corrected. After a few weeks the problem was brought to Dr. Beaumier's attention. The subject was told that this condition would eventually correct itself. At approximately the fifteenth week of rehabilitation, the condition did correct itself. A specific answer for the occurrence of this condition is yet unknown to this researcher.

Coordination exercises were begun late in the rehabilitation program. It is the opinion of this researcher that these exercises could have been begun almost immediately with the removal of the short leg cast. The subject took much longer than expected to regain full coordination of the leg muscles and ankle joint. This did cause a delay in the full recovery of the subject. Coordination is sometimes neglected in the area of sport rehabilitation programs. There is so much emphasis on strength and endurance that coordination is left until the end or entirely forgotten. Total rehabilitation is not complete until strength, endurance, flexibility and coordination are normal (13). All four must be incorporated into the rehabilitation program with equal emphasis.

This rehabilitation program gave good results for this particular subject, but to use it as a set guideline for future programs would be unsound. It has only been used on this one subject; it needs to be used on other subjects before it can be truly accepted. Another factor which would limit the use of this program is time. This subject was able to spend two to three hours a day in treatment. Only in an athletic training room setting would this time allotment be feasible.

Again this rehabilitation program should not be used as a set standard, but it can be used as a general guideline for athletic trainers and physical therapists who may have the opportunity of working with such an injury.

Summary

A review of the anatomical structure, mechanical function, and mechanism of injury of the Achilles tendon was presented. The surgical procedure, description and results of a specifically developed rehabilitation program were also presented.

APPENDICES

APPENDIX I

TERMINOLOGY

1. Anterior--Before, or in front of.

2. Atrophy--The reduction in size of a structure.

3. Biarticular--Refers to two joints.

4. Bursa--A padlike sac or cavity found in connecting tissue usually in the vicinity of joints. Acts to reduce friction between tendon and bone, tendon and ligament, or between other structures where friction is likely to occur.

5. Bursitis--Inflammation of a bursa, especially those located between bony prominences and muscle or tendon.

6. Calcaneus--The heel bone, or as calcis.

7. Cariocas--A lateral movement using alternating cross over steps.

8. Collagen--A fibrous insoluble protein found in connective tissue, including skin, bone, ligaments and cartilage.

9. Distal--Farthest from the center, from a medial line, or from the trunk.

10. Dorsiflexion--Movement of a joint toward the dosrum or posterior aspect of the body.

11. Elastin--A protein substance forming the principal constituent of yellow elastic tissue.

12. Endotenon tissue--Tissue within the structure of the tendon.

13. Fibrosis--Abnormal formation of fibrous tissue.

14. Golgi tendon--A nerve apparatus which detects degree of tension in tendons.

15. Hematoma--A swelling or mass of blood (usually clotted) confined to an organ, tissue, or space and caused by a break in a blood vessel.

16. History of injury--How an injury occurred.

17. Hypotrophy--Progressive degeneration and functional loss of cells and tissues.

18. Insertion--The manner or place of attachment of a muscle to the bone so that it moves.

19. Integument--A covering.

20. Leg--From the knee to the ankle.

21. Longitudinal clefts--Longitudinal division or split.

22. Mechanism of injury--The action which occurs to cause an injury.

23. Musculotendinous--Composed of both muscle and tendon.

24. Origin--The more fixed attachment of a muscle.

25. Overload principle--To place a high amount of resistance upon a muscle action.

26. Pacinian corpuscles--Encapsulated sensory nerve endings found in subcutaneous tissue and many other parts of the body. These corpuscles are sensitive to keep or heavy pressure.

27. Plantarflexion--Movement of a joint toward the anterior aspect of the body.

28. Posterior--Toward the rear or caudal end; opposed to anterior.

29. Proprioceptor--A receptor that responds to stimuli originating within the body itself, especially those responding to pressure, position or stretch.

30. Proximal--Nearest the point of attachment, center of the body, or point of reference.

31. Reticulin--An albuminoid or scleroprotein substance in the connective tissue framework of reticular tissue.

32. Subtalar joint--Below the talus.

33. Tendino--Periosteal Insertion--Insertion of a tendon unto a bone.

34. Tendonitis--Inflammation of a tendon.

35. Thigh--From the hip to the knee.

36. Triceps Surae--The combination of the gastrocnemius and soleus into one muscle mass.

Medical Definitions from Taber's Cyclopedic Medical Dictionary.

APPENDIX II

SURGICAL REPORT

the united hospital
GRAND FORKS, NORTH DAKOTA 58201

☐ NORTH UNIT

☒ SOUTH UNIT

PREOPERATIVE DIAGNOSIS: Ruptured tendon of Achilles, left heel.

POSTOPERATIVE DIAGNOSIS: Same.

OPERATIVE PROCEDURE: 6-5-80: Repair of tendon of Achilles, left heel and application of long leg cast, left lower extremity.

SURGEON: Beaumier

DESCRIPTIONOF OPERATION: The patient was anesthetized, placed in the prone position, the left lower extremity was prepped and draped in the usual sterile manner using pneumatic tourniquer to 250 mm. of Mercury. The longitudinal incision was made at the lateral side of the heel cord, the subq tissue was then undermined carefully to the medial side, complete rupture was noted at the muscular-tendinous junction proximally. We then trimmed this area off very carefully and after doing this we then plantar flexed the foot and then selected a #18 gauge wire with a long curved needle and straightening this out we passed the heavy gauge wire through the proximal portion of the tendon from medial to lateral and placed it in a cross type fashion through the proximal portion of the ruptured tendon and then placing it down through the distal portion of the tendon outwardly and then through the heel itself. After the wires had intwined then we pulled these snugly together this brought the area together very nicely and then we pared the roughened edges with interrupted sutures of Neuralon in an interrupted mattress fashion, reinforced with 2-0 Vicryl suture as well. This brought the area very nicely together, we then repaired the subq layer of fat with 3-0 Vicryl, the skin was then closed with interrupted skin staples. A pullout wire was utilized prior to the closure and we then placed a Betadine gauze sterile dressing over the wound site itself and then placed a long leg cast with the foot in a plantar flexed position and the knee in a flexed position as well. Upon release of tourniquet the toes pinked up immediately, the patient tolerated the procedure very well.

John H. Beaumier, M.D.
LS 6-5-80 D/T #2

12651 C
23
309-1 BEAUMIER 2837250
1122 S 19TH ST GF ND

7181 030 MAR 80

DATE OF OPERATION 6/5/80

RECORD OF OPERATION

APPENDIX III

STRETCHING PROGRAM

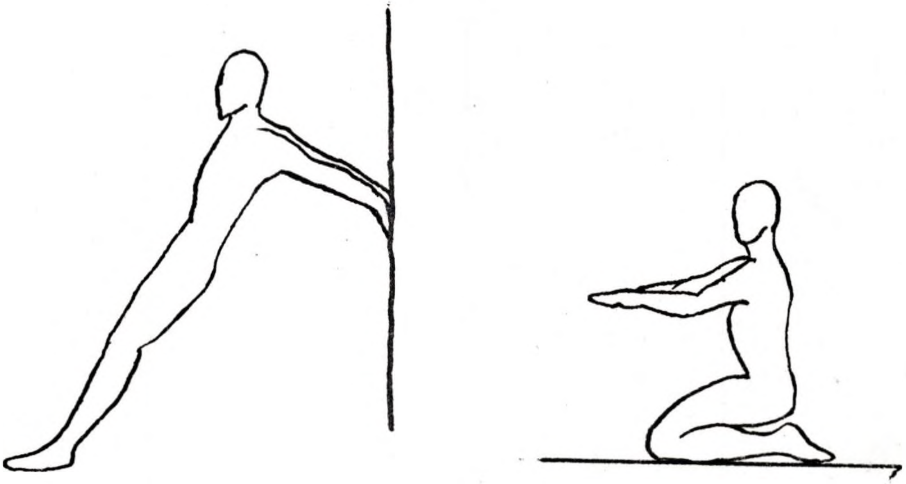
1. Begin close to the wall with the heel flat on the surface. Lean forward to stretch the gastrocnemius (the largest muscle of the calf) muscle. Progress by moving further from the wall. (Example: five sets of 30 seconds of static stretching.) This is a variable depending on the needs of the individual.

2. The previously described exercise can also be performed over the edge of a step to increase the amount of stretching placed on the muscle or tendon.

3. This is an often neglected exercise but one that I feel holds the key to the prevention (and rehabilitation) of the Achilles tendon in endurance athletes. When participating in endurance activities, the soleus muscle is strongly recruited because it is predominantly an endurance-type muscle. Thus, to effectively stretch the soleus muscle, without interference of the gastrocnemius muscle, one should bend the knees. By bending the knees, the gastrocnemius, which is a biarticular muscle, is eliminated because it is placed on slack. So now the stretching force is primarily isolated on the soleus muscle.

4. It is also a good idea to stretch the muscles on the contralateral (the opposite) side of the leg to maintain a normal balance. It also prevents the anterior lower leg muscles from shortening and causing the Achilles tendon to be stretched all the time. This constantly

stretched position could also lead to trauma of the Achilles tendon because of overuse being placed on it in a stretched position.



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