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A Case Study of a Recurrent Anterior Tibial Compartment Syndrome

M. Curtis Robinson

A CASE STUDY OF A

RECURRENT ANTERIOR TIBIAL COMPARTMENT SYNDROME

by
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This Thesis submitted by M. Curtis Robinson 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
(Chairperson)

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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.

J. William Jr. Anson
Dean of the Graduate School

Permission

Title A Case Study of a Recurrent Anterior Tibial Compartment Syndrome

Department Health, Physical Education and Recreation

Degree Master of Science

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Signature M. Curtis Robinson

Date July 21, 1983

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ABSTRACT

The purpose of this thesis was to investigate the anatomical structure, mechanism of injury, treatment, surgery, and rehabilitation of one recurrent anterior tibial compartment syndrome.

A case study of one twenty-six-year-old female subject was the basis for this study. The procedure used for the subject's rehabilitation program was presented.

The results of this rehabilitation program were satisfactory. The subject was able to return to her program of jogging and six months after surgery, was running 4 to 6 miles a day, three to four times a week.

The rehabilitation program may be used as a guideline for future programs. It was designed specifically for one individual, and therefore, should not be generalized to a population.

CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

Introduction

With an ever increasing number of participants in sports and sports related activities has come a tremendous upsurge in the interest of sports injuries. Recognizing the nature and extent of the injury is the first step in providing the athlete with the proper care required. The anterior tibial compartment syndrome is a rare occurrence in sports making it essential that one recognizes its signs and symptoms when they do occur.

The purpose of this thesis was to investigate the anatomical structure, mechanism of injury, treatment, surgery, and rehabilitation of one recurrent anterior tibial compartment syndrome.

This case study was done on one twenty-six-year-old female subject. The surgical procedure used was one of several methods of fasciotomy that could have been used. This study does not intend to imply that because it was chosen for this particular subject it was a better surgery to use, but simply the choice of the attending physician. The results of the rehabilitation program are specific to this one subject, and therefore, should not be generalized to a population.

Review of the Literature

Anatomy and Function

The muscles that are contained in the anterior compartment of the leg are primarily the muscles that dorsiflex the foot. Among this group of muscles is the tibialis anterior, the extensor digitorum longus, the extensor hallucis longus, and, in the distal extent, the peroneus tertius (Mubarak and Hargens 1981). A common origin is shared by each of these muscles along the interosseous membrane. These muscles also have origins from the anterior fibula, the lateral condyle and surface of the tibia, and the deep fascia (Galstad 1979). The tibialis anterior inserts on the medial and plantar surfaces of the first metatarsal bone thus acting to dorsiflex and invert the foot. The extensor hallucis longus inserts into the base of the distal phalanx of the first toe to allow for extension of the proximal phalanx and also to dorsiflex and invert the foot. The extensor digitorum longus attaches to the first four toes in a similar way as the extensor hallucis longus attaches to the first toe and also functions in a likewise manner. The peroneus tertius, inserting into the base of the fifth metatarsal, acts to dorsiflex and pronate the foot (Galstad 1979; Daniels and Worthingham 1972; Jacob and Francome 1974). (Refer to Appendix I for terminology.)

All muscles of the anterior compartment are innervated by the deep peroneal nerve, which has its origin in the fourth and fifth lumbar and first sacral nerve roots. This nerve enters the compartment proximally around the fibular neck and exits distally as the anterior tibial nerve, which supplies sensation to the first web space of the foot. A sensory loss on the dorsum of the first two toes and foot drop may occur as a

result of compression on the deep peroneal nerve (Galstad 1979; Mozes, Ramon, and Jahr 1962; Mubarak and Hargens 1981).

The anterior compartment's blood supply comes from the anterior tibial artery, which continues in the foot as the dorsalis pedis artery (Galstad 1979; Jacob and Francome 1974; Mubarak and Hargens 1981; Mozes, Ramon, and Jahr 1962).

The anterior compartment muscles are enclosed in a nonyielding, non-extensible compartment of bone and fascia. The compartment is bound posteriorly by the tibia, interosseous membrane and fibula. The anterior border is formed by the crural fascia and the lateral border by the anterior intermuscular septum, which is an extension of the crural fascia to the fibula (Mubarak and Hargens 1981). Superiorly, the compartment is bound by the tibiofibular joint and inferiorly by the extensor retinaculum. Because the compartment is tightly covered and has a major neurovascular supply, it is quite susceptible to a compression syndrome (Galstad 1979).

While walking, the anterior tibial, extensor digitorum longus, and extensor hallucis longus muscles undergo an eccentric contraction in the latter part of the stance phase, a concentric contracture throughout the swing phase, and another eccentric contraction from the time the foot contacts the ground until it is set flat. However, as the speed of gait increases, significant changes occur in the function of the anterior compartment muscles. While the swing phase continues with a concentric contraction producing dorsiflexion to allow for toe clearance, the anterior compartment muscles now remain active during approximately 50% of the stance phase and cease to function just after plantarflexion

of the foot begins. The anterior compartment muscles seem to offer stability as the foot contacts the ground and a way of accelerating the tibia over the fixed foot, providing a means of efficient forward movement during running (Mann 1982).

Mechanism of Injury

A compartment syndrome occurs as a result of an increased fluid tissue pressure in a closed fascial compartment compromising the circulation and function of tissues within that space (Hargens and Akeson 1981; Mubarak and Hargens 1981; Matsen and Krugmire 1978; Matsem 1975; Mubarak et al. 1978). A rapid swelling of muscle tissue within the noncompliant compartment along with an accumulation of hemorrhage or edema, or both, causes an increase in intramuscular fluid pressure that in turn produces ischemia (Mubarak and Hargens 1982; O'Donoghue 1976).

An anterior compartment syndrome can be caused as a result of interference with the major vascular supply, direct injury, or from strenuous exercise of an unconditioned muscle (Mubarak and Hargens 1982; Mubarak et al. 1978; O'Donoghue 1976; Bradley 1973; Hughes, Lineberger, and Bowers 1961). The condition is more common in males than females and can occur at any age. However, if the instances associated with vascular disease were eliminated, the average age under these circumstances would be twenty-five years (Bradley 1973).

At onset there is a severe pain over the anterior compartment muscles with a loss of function making dorsiflexion of the foot impossible, resulting in a drop foot. Any contraction of the musculature, active or passive causes increased pain. The area has an increased local temperature with swelling and a red, glossy appearance. The leg

is markedly tender with hardness over the involved space. A decreased peripheral pulse may or may not be evident. In addition, there may be sensory loss over the base and web of the first toe (Galstad 1979; Getzen and Carr 1967; Bradley 1973; Leach, Hammond, and Stryker 1967; O'Donoghue 1976; Hughes, Lineberger, and Bowers 1961; Mubarak and Hargens 1982; Deutsch and Fashouer 1982; Hoerner 1981; Waddell 1977).

Compartment syndromes are classified into two types: acute and recurrent. An acute compartmental syndrome is characterized by a rapid increase in intracompartmental fluid pressure to a level and duration whereby immediate decompression is required to prevent irreversible tissue damage. In contrast, the recurrent or chronic compartment syndrome symptoms dissipate with rest and the person is asymptomatic between recurrences (Veith, Matsen, and Newell 1980). The recurrent anterior tibial compartment syndrome is usually found in young male athletes and military recruits. There is normally a certain distance covered to bring on pain, which may persist into the night. Although symptoms may dissipate, they reappear during the next period of exercise. Mubarak and Hargens (1982) report that unless exercise is stopped, the recurrent compartment syndrome may develop into an acute case requiring emergency surgical decompression.

Evaluation and Care

Upon examination, a complete history of where, when, and for how long the symptoms have been present should be gathered. To correctly evaluate an anterior tibial compartment syndrome, the examiner must have the knowledge to recognize the symptoms of this condition. With these in mind, the evaluation should include a visual check of the

involved surface area, palpation of the pedal pulses (dorsalis pedis and posterior tibial) for a peripheral pulse, and pinprick assessment of sensory deficit within the first webbed space. In addition, manual testing the compartment muscles for range of motion and strength in dorsiflexion and toe extension is beneficial (Galstad 1979; Hoppenfeld 1976; Matsen 1975).

Measuring tissue pressure within the compartment space is considered to be the best objective test for determining the need for decompression. A needle or catheter inserted into the compartment aids the physician in deciding whether or not a fasciotomy is indicated. Mubarak (1982) reports several other means which are not as significant as tissue pressure measurement, but are occasionally used by the physician for evaluation of the syndrome: electromyography and nerve conduction, venograms, sodium chloride clearance, arteriography and doppler.

Occasionally, the following conditions will present themselves in a similar way to an anterior compartment syndrome and need to be differentiated by the physician: intermittent claudication due to partial femoral artery obstruction, stress fractures of the tibia or fibula, medial tibial syndrome, tenosynovitis, infection, shin splints, cellulitis, deep abscess, thrombophlebitis, acute osteomyelitis, peroneal nerve lesions, thromboangitis obliterans, and myositis (Hughes, Lineberger, and Bowers 1961; Mubarak 1982).

Immediate care for the anterior compartment syndrome includes the application of ice. Elevation of the affected limb and compression are contraindicated because of the already existing conditions of ischemia and increased intracompartmental pressure (Galstad 1979; Matsen 1975).

In acute cases, the literature always stresses immediate fasciotomy to prevent the muscles from going on to ischemic necrosis (O'Donoghue 1976; Mubarak and Hargens 1981; Mubarak 1982; Mubarak and Hargens 1982; Leach, Hammond, and Stryker 1967; Mavor 1956; Veith, Matsen, and Newell 1980; Matsen and Krugmire 1978; Matsen 1975; Waddell 1977; Bradley 1973; Stark 1969; Mozes, Ramon, and Jahr 1962; Rorabeck and Clarke 1978; Reneman 1975; Getzen and Carr 1967; Mubarak et al. 1978; Hughes, Lineberger, and Bowers 1961; Whitesides et al. 1975). The acute syndrome is an extreme medical emergency and any delay in fasciotomy may result in a complete drop foot and irreversible tissue damage. With the recurrent compartment syndrome, a fasciotomy is also advised if the individual wishes to continue his/her previous level of activity. However, since the symptoms tend to dissipate with rest, there is not the urgency for fasciotomy that is present with the acute syndrome. Some patients, after hearing the diagnosis and treatment involved, choose to simply curtail their activities (Mubarak and Hargens 1982). Reneman (1975) found ten individuals diagnosed with recurrent anterior compartment syndrome who refused fasciotomy to all be symptomatic at ten to twelve months' follow-up.

CHAPTER II

CASE STUDY

The following is a case study of one twenty-six-year-old female amateur athlete who developed a recurrent anterior tibial compartment syndrome through exercise. The subject was a consistent runner of 2 to 6 miles, five to seven days a week for eight years. The study began following the subject's surgery.

History

During the latter days of September 1982, upon completing her run, the subject began suffering severe pain over the anterolateral portion of her right leg. The foot and ankle were extremely weak and dorsiflexion was impossible. The foot dragged with each step but after thirty to forty-five minutes of "walking it out," the severe pain subsided. However, a dull ache and weakness remained present.

As early as the previous winter, the subject had experienced this severe pain after strenuous exercise. In addition to the leg pain, the area over the anterior compartment would swell, become hot, glossy, and fiery red. However, all symptoms disappeared aside from a numbness between the first and second toes, which she had also begun to notice.

The incident which convinced the subject to seek medical attention came on November 4, 1982. Upon returning home from her usual run, she

was unable to move her right leg. After intense concentration, she was able to drag the leg along and get into the house.

The subject was examined by Dr. Benson, an orthopaedic surgeon, on the eighth of November and the condition was diagnosed as a recurrent anterior compartment syndrome. A compartment release was scheduled for the nineteenth of November.

Surgery

As stated earlier, this surgery is one of several methods of fasciotomy that could have been used. It is not the intention of this researcher to imply that it was the best method to use, nor is it being said that there is a better surgery for this condition. It was simply the method of surgery which Dr. Benson chose to use on this patient. (Refer to the Appendices for the surgical report.)

Figure 1. Level of incisions for fasciotomy.

Rehabilitation

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

Rehabilitation Program

Phase I: Maximum Protection

- A. No weight bearing
  - 1. ambulation with crutches progressing to crutch walking
- B. Muscle setting
  - 1. foot and ankle
  - 2. calf
  - 3. thigh
- C. Reduction of swelling
  - 1. ice
  - 2. compression
  - 3. elevation

Phase II: Restoration of Function and Range of Motion

- A. Full weight bearing
  - 1. walking without use of crutches
- B. Exercises for increased range of motion
  - 1. heel walking
  - 2. stretching
  - 3. swimming

4. drawing letters of the alphabet in the air with ankle and foot

Phase III: Restoring Strength and Endurance

A. Isometric ankle wrestling
   1. increases strength of musculature
B. Toe raisers
   1. develops strength and endurance of extensors
C. Eversion with elastic cord
   1. develops strength and endurance of eversion musculature
D. Walking
   1. increases cardiovascular and muscular endurance
E. Jogging
   1. increases cardiovascular and muscular endurance

Description of Rehabilitation Phases

Phase I: Maximum Protection

The intent of this phase was to limit the extent of the injury. The patient was provided with crutches following surgery and instructed to use them until it was comfortable to put weight on the injured leg.

O'Donoghue (1976) stated that the optimal time for beginning rehabilitative exercises is approximately twenty-four hours following surgery. Whenever a muscle group is inactive, atrophy and weakness set in and further delay return to normal function. Circumferential measurement of the leg was taken and found to be somewhat decreased. The subject performed muscle setting exercises for maintaining musculature

at unscheduled times with varying repetitions throughout the day during Phase I by tightening the musculature of the thigh, calf, foot and ankle for a count of six seconds and then relaxing. Active strengthening exercises were employed into the rehabilitation program (Phase III) for return of musculature.

Care for reduction of swelling and limiting of further injury was also provided in the form of ice, elevation, and a pressure wrap.

Phase II: Restoration of Function and Range of Motion

Developing flexibility will aid in the restoring of joint motion through the full range without any unnecessary restrictions (Klafs and Arnheim 1977). Included in Phase II are a variety of exercises for the restoration of function and range of motion including heel walking, drawing letters of the alphabet in the air with foot and ankle, weight bearing passive exercises in dorsiflexion (heel on floor, lean forward, alternate knee bent and straight), and swimming (Fiore and Leard 1980).

Heel walking is performed by walking in a pattern keeping the toes as far off the ground as possible. Short, choppy steps are taken. A progression of walking up an incline in the same manner, or carrying a weighted object is begun after being able to heel walk for 100 feet or two full minutes (O'Donoghue 1976; Fiore and Leard 1980).

Figure 2. Heel walking.

A pool workout was also beneficial for the subject as it allowed her to go through complete range of motion without full weight bearing. The buoyant affect of the water reduced the amount of pressure placed on the injured leg. The pool workout included swimming with a flutter kick and jogging.

Phase III: Restoring Strength and Endurance

The exercises of isometric ankle wrestling, toe raisers and eversion with an elastic cord allow for strengthening the ankle through its full range of motion specific to its normal daily function. Thus, these exercises were incorporated with the exercises of Phase II as soon as they were able to be performed properly without pain (Fiore and Leard 1980).

Isometric ankle wrestling is performed by sitting and placing one ankle over the other. An outward force is exerted by both ankles so they are firmly pressing against each other. They are then held for

ten seconds, released, and repeated ten times. As the ankles become stronger and less stiff, they may move in and out against each other as you push, and again lasting for ten full seconds and repeated ten times (O'Donoghue 1976).

Figure 3. Isometric ankle wrestling.

Toe raisers are begun with both feet on the floor. When the foot becomes more flexible, a progression is made to standing on the edge of a step or piece of wood. With the heels stretching below the level of the toes, the subject rises up lifting the heels up over the toes. After twenty to twenty-five repetitions can be comfortably accomplished standing on both feet, switch to standing on only one foot. A progression is made to holding a weighted object after twenty to twenty-five repetitions can be performed while standing on one foot (O'Donoghue 1976).

Figure 4. Toe raisers beginning flat on floor with both feet.

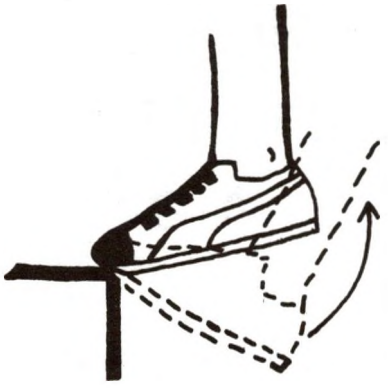

Figure 5. Toe raisers advanced to step with one foot only.

Eversion with an elastic cord strengthens the peroneal muscles. With this exercise, the subject sits with knees bent and holds the end of the cord in a manner shown in Figure 6. As dorsiflexion and eversion of the forefoot occurs, tension of the cord can be adjusted by stretching it to increase the difficulty of the exercise. Three sets of ten repetitions is followed by an endurance run of twenty-five repetitions.

Figure 6. Eversion with elastic cord.

Figure 7. Uniaxial PRE machine used for testing strength in ankle inversion, eversion, and dorsiflexion.

It was the recommendation of Dr. Benson (1982) that there be a gradual return to jogging type exercises. On February 8, 1983, the subject was examined by Dr. Benson and given permission to begin some light jogging.

Dismissal

On May 5, 1983, the subject was examined and released by Dr. Benson. The symptoms of the injury were significantly improved. The subject was back on a running schedule of 4 to 6 miles a day, three to four times a week.

CHAPTER III

DISCUSSION AND CONCLUSION

This rehabilitation program seemed to give favorable results. The subject's strength and musculature returned to normal. She was able to continue her normal routine of jogging.

During the first two months following surgery, the subject experienced occurrences of glossy redness over the anterior compartment, pressure, and increased swelling similar to the symptoms she had experienced previous to surgery. This usually occurred when she was on her feet for a great deal of the day or was out shopping for an extended period of time. Therefore, in the opinion of this researcher, the conservative approach used with rehabilitating this particular injury seems well justified. Jogging exercises were not incorporated into the program until three months following surgery.

It was stated earlier that anterior compartment syndromes related to exercise were usually brought about by exertion of an unconditioned muscle. Therefore, it seems peculiar that this subject, a regular jogger for eight years, would develop this condition. An explanation for this is yet unknown to this researcher.

This program of rehabilitation was designed to fit the specific needs of this subject. Results were acquired from the evaluation of only one individual. Therefore, although this rehabilitation program

may be used as a general guideline in further studies, it would be scientifically unsound to apply it to a general population.

Summary

A review of the anatomical structure, mechanism of injury, and treatment of an anterior tibial compartment syndrome was presented. In addition, the surgical procedure and results of a specifically designed rehabilitation program were also presented.

APPENDICES

APPENDIX I

TERMINOLOGY

1. Anterior — Situated or directed toward the front.

2. Arteriography — Radiography of an artery or aterial system after injection of a contrast medium into the blood stream.

3. Atrophy — The reduction in size of a structure.

4. Cellulitis — Inflammation of cellular tissue.

5. Concentric contraction — A shortening contraction of the muscle.

6. Condyle — A rounded projection on a bone, usually for articulation with another bone.

7. Contraindicate — To give indication against the advisability of a particular treatment.

8. Crural — Pertaining to the leg.

9. Distal — Farther from any point of reference.

10. Dorsiflexion — Backward flexion or bending, as of the hand or foot.

11. Dorsum — The posterior or superior surface of a body or body part, as of the hand or foot.

12. Eccentric contraction — A lengthening contraction of the muscle.

13. Edema — An abnormal accumulation of fluid in intercellular spaces of the body.

14. Electromyography — The recording and study of the intrinsic electrical properties of skeletal muscle.

15. Eversion — Turning outward.

16. Fascia — A sheet or band of fibrous tissue such as lies deep to the skin or invests muscles and various body organs.

17. Fasciotomy — Incision of a fascia.

18, History of injury — How an injury occurred.

19. Inferior — Situated below, or directed downward.

20. Innervation — The distribution or supply of nerves to a part.

21. Intermittent claudication — Pain, tension, and weakness in the legs on walking, which intensifies to produce lameness.

22. Inversion — Turning inward.

23. Ischemia — Lack of blood supply to a part.

24. Isometric — Exercise performed against stable resistance, without change in the length of the muscle.

25. Lateral — Pertaining to a side.

26. Leg — The lower limb from knee to foot.

27. Lesion — Any pathological or traumatic discontinuity of tissue or loss of function of a part.

28. Medial — Situated toward the midline of the body.

29. Myositis — Inflammation of a voluntary muscle.

30. Necrosis — Death of a tissue or organ.

31. Neuromuscular — Pertaining to nerves and muscles.

32. Osteomyelitis — Inflammation of bone, localized or generalized, due to pyogenic infection.

33. Phalanx — Any bone of a finger or toe.

34. Posterior — Directed toward or situated towards the back; opposite of anterior.

35. Proximal — Nearest the point of attachment, center of the body, or point of reference.

36. Retinaculum — A structure that retains an organ or tissue in place.

37. Superior — Situated above, or directed upward.

38. Syndrome — A group of typical symptoms or conditions that characterize a deficiency or a disease.

39. Tenosynovitis — Inflammation of a tendon sheath.

40. Thrombophlebitis — Inflammation of a vein associated with thrombus formation.

41. Venogram — A phlebogram; a radiogram of a vein filled with contrast medium.

42. Weight bearing — The allowance of body weight being placed on the extremity or extremities.

APPENDIX II

SURGICAL REPORT

#11515

McKENNAN HOSPITAL
Sioux Falls, South Dakota

OPERATIVE REPORT

OUTPATIENT SURGERY #411593
HARTE, BARBARA L.
720 1st St. NW
Watertown, SD 57201
11-19-82
G. M. Benson, M.D.

DOB: 1-12-56

DATE OF OPERATION: 11-19-82

PRE-OPERATIVE DIAGNOSIS: Recurrent anterior compartment syndrome.

SURGEON: G. M. Benson, M.D. ASSISTANT:

POST-OPERATIVE DIAGNOSIS: Same.

OPERATION: Anterior compartment release.

OPERATIVE PROCEDURE: The patient was anesthetized with general anesthesia. The right leg and foot was prepped and draped in routine fashion and a high thigh tourniquet was inflated. A 2 cm. incision was made over the anterior compartment proximally and a long Metzenbaum scissors was placed down over the fascia and the fascia was split distally as far as we could reach with this scissors. Another incision was then made over the distal third of the anterior compartment and a long scissors was once again placed through the fascia and the fascia was divided in its distal portion. This gave us satisfactory release of the anterior fascia over the anterior compartment. The wounds were then irrigated and closed. A dressing was applied. The patient tolerated the procedure well and went to Recovery in satisfactory condition.

GMB/mlh
cc
11/19/82 d/t

G. M. Benson, M.D.

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