5-1-1982

An Anatomical Review and Case Study of an Anterior Cruciate Ligament Tear

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AN ANATOMICAL REVIEW AND CASE STUDY OF AN ANTERIOR CRUCIATE LIGAMENT TEAR

by
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Bachelor of Science, West Chester St. College, 1980

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Science

Grand Forks, North Dakota

May
1982

An Anatomical Review and Case Study of an Anterior Cruciate Ligament Tear

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The University of North Dakota, 1982

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A case study of one 19-year-old male football player who suffered a tear on his anterior cruciate ligament was the basis of this study. A daily record of the subject's rehabilitation program which was designed by this researcher for this particular individual was presented.

The results of this rehabilitation program at the time of this study were satisfactory. The subject had regained full strength and coordination. He had returned to daily activities and was expecting to return to football at the beginning of the season.

The rehabilitation program used was structured for an athletic individual who was in otherwise excellent

overall physical condition. He had an extremely high level of self motivation, and could afford to spend two hours per day in therapy.

This program can be used as a guideline for future programs, but should not be transferred to the general population. The outcome of this thesis is based on one individual, so one should not make inferences to the general public.

This Thesis submitted by Amy Ellen Packer 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.

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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 Johnson
Dean of the Graduate School

Permission

Title An Anatomical Review and Case Study of an Anterior Cruciate Ligament Tear

Department Health, Physical Education and Recreation

Degree Master of Science

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Signature Amy Packer

Date 4/29/82

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ACKNOWLEDGMENTS

I would like to give special thanks to Bruce Johnson and Dr. Brian Briggs for their help and guidance throughout my two years at the University of North Dakota.

I would like to thank the following people who have all contributed to this thesis: Dr. Walt Koneig, Dr. Carl Miller, Dr. Paul Wright, Dr. Harvey White, A. G. Edwards, and Dee Dee Evavold.

I would also like to thank the subject of this thesis, Neil Stock, for his cooperation throughout this study.

Finally, I would like to mention my parents, Doris and Bert Packer, for their constant support and understanding.

ABSTRACT

The intent of this thesis was to investigate the anatomical structure, mechanism of injury, treatment, surgery, and rehabilitation of one anterior cruciate tear. The anatomical structure, mechanism of injury, treatment, surgery, and rehabilitation program were described.

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CHAPTER I

INTRODUCTION, REVIEW OF THE LITERATURE AND TERMINOLOGY

Introduction

Resulting from the great increase of the popularity of sports participation in both competitive and recreational sports, physicians have noticed an abundance of sports-related injuries which require care. The knee joint, due to its vulnerability and complex anatomy, has accounted for a large portion of these injuries (1). One such injury, the anterior cruciate rupture, has been labeled as "the beginning of the end for the knee" (2).

The intent of this thesis was to investigate the anatomical structure, mechanism of injury, treatment, surgery, and rehabilitation of one anterior cruciate tear.

This case study was done on one otherwise healthy, 19-year-old male football player at the University of North Dakota. The surgical procedure employed was one of many that could have been used. This study does not intend to imply that this surgical method was the optimum method, but simply the choice of the attending physician. The results of the rehabilitation program are specific to this one individual and therefore cannot be generalized to a population.

Review of the Literature

Anatomy and Function

Connecting the femur and tibia is the anterior cruciate ligament which acquires its name from its tibial origin. The anterior cruciate arises from the anterior part of the tibial plateau in front of the tibial spine. It extends upward and backward through the supracondylar notch and is inserted into the inner back portion of the outer condyle of the femur. As the ligament reaches backward it rotates ninety degrees so that its insertion is spread out over a broad flattened area (3, 4).

The anterior cruciate is described to have two main parts, an anteromedial band, and a posterolateral band. Due to the arrangement of its fibers, tension is generated through complete range of motion. For simplification, the anteromedial band is tight at ninety degrees of flexion. The posterolateral band, while somewhat loose in flexion, becomes tight in full extension.

Vascularily, the anterior cruciate is supplied from the medial genicular branch of the popliteal artery (3, 5). Trauma which disrupts this blood supply causes this ligament to atrophy (3).

The function of the anterior cruciate has been described as being complex. Its main claim of function is to prevent forward displacement of the tibia on the femur (6, 7, 8). Other functions of the anterior cruciate

have been described by researchers. Some feel the primary role is to prevent relative hyper-extension of the knee (9). It has also been felt to be of aid in controlling rotary movement (3, 5, 9-16). The anterior cruciate may act as a guide for internal rotation of the tibia (3, 13-16), as well as aiding external rotation when the knee is flexed (3, 5, 9, 13).

Due to its anatomical structure and numerous functions, some physicians feel that the anterior cruciate ligament is the primary stabilizer of the knee (2, 3, 17).

Mechanism of Injury

Injury to the anterior cruciate ligament is quite common in athletics. In one study it accounted for sixty-nine percent of those knees that came to surgery for internal derangement of various types (18).

The initial injury is associated with activities that involve jumping, stopping, and cutting maneuvers which cause the foot to be firmly planted with the knee extended and quadriceps contracted. The majority of the time a twisting force is involved in such a way that the tibia internally rotates on the femur. The subsequent tension that is transmitted to the anterior cruciate ligament can cause it to rupture (15).

Often the person describes having felt a "pop" (5, 14, 15, 19, 20), and had the sensation that the knee did "go out" or "give way" (11, 14). One researcher claimed

that 90 percent of his patients who felt a "pop" had anterior cruciate ruptures (5). The "giving way" sensation was caused by anterior subluxation of the lateral tibial plateau on the lateral femoral condyle, with the knee in slight flexion while spontaneously reducing itself as the knee reached thirty to forty degrees of flexion (19).

Surgical Procedures and Treatment

There are many different opinions on how to surgically repear an anterior cruciate ligament deficiency. There are those who use primary repair in which an attempt is made to repair the original ligament (18, 21 - 23). Others follow it by using a secondary repair where they use other structures to reconstruct the joint (21, 24).

Contrary to the philosophy of acute surgical repair is that of non-surgical treatment. In a case where an isolated tear of the anterior cruciate is suspected the joint is aspirated and the individual is immediately placed on an exercise program. There is no attempt to repair the damage (18, 25).

Some researchers feel that an isolated ligament injury probably does not exist in the knee (21). Even when an acute injury appears to be isolated to one structure, other elements can be involved. There may be interstitial damage that is difficult to see and secondary deterioration due to abnormal forces being applied to the joint (21, 26, 27).

Follow-up Studies

Few studies have been conducted to determine long range effects of anterior cruciate tears, however there have been studies done to measure more immediate degenerative changes.

One study done in North Carolina evaluated fifty-three knees with untreated anterior cruciate ruptures. These knees were evaluated for approximately ten years following the injury. It was found that patients with equal thigh circumference were better off than those with atrophy. Of these patients only a few felt their knee was relatively normal, 72 percent returned to strenuous sports, and 47 percent felt they had no restrictions because of their knee (2).

A study done in California on thirty patients who had a combined anterior cruciate tear along with a meniscus tear claimed that 83 percent of their patients returned to full athletic activity. Thirty-three percent were experiencing occasional giving way while 20 percent complained of swelling and stiffness after a strenuous workout. The follow-up ranged from one and one-half to four years. None of the cruciates were repaired (28).

Another study done in California dealt with a five-year follow-up of isolated anterior cruciate tears which had undergone primary repair. Of the 32 patients in the study, 12 noted impairment of ordinary activities and 24

noted impairment of athletic activities. Seventy-one percent indicated pain, 66 percent had swelling, 71 percent had stiffness, and instability was felt by 94 percent. Seventeen of the patients had suffered additional injury while 12 required a second surgery. Five patients were said to be symptom free (27).

Many patients who have anterior cruciate insufficiency will claim they are doing well but cannot function as normal. In many cases the patient learns to compensate by avoiding maneuvers that cause instability (29). This has been found in patients with both primary and/or secondary repairs along with patients who have gone untreated (15). Many of the repairs appear to function well in the early stages but later failed with repeated exposure to stress (20).

Terminology

1. Active--Movement done under patients own power.
2. Arthrogram--Radiological test showing x-ray of meniscus.
3. Arthroscope--A surgical tool used like a telescope to look inside a joint.
4. Aspiration--The procedure of drawing fluid out of a joint utilizing a syringe.
5. Atrophy--The reduction in size of a structure.
6. Cardiovascular--Contains all those factors associated with the heart and blood vessels.

7. Chondromalicia--Abnormal softening of cartilage.
8. Dorsal Flexion--Movement of a joint toward the dorsum or posterior aspect of the body.
9. Effusion--Escape of a fluid into a part.
10. Endurance--The ability to persist in physical activity and resist muscular fatigue.
11. Femoral condyle--A rounded projection on the distal end of the femur.
12. Hemarthrosis--Blood in a joint cavity.
13. Isokinetic--Exercise in which the velocity of muscular contractions has been made constant.
14. Isometric--Exercise performed against stable resistance, without change in the length of the muscle.
15. Isotonic--Exercise without appreciable change of force of the muscular contraction, with shortening of the muscle.
16. Knee imobilizer--An orthopaedic brace used to support the knee joint.
17. Lateral--Denotes a position farther from the midline of the body.
18. Medial--Pertaining to or situated toward the midline.
19. Meniscus--Referring to the cartilage of the knee joint.
20. Neuromuscular--Pertaining to the nerves and muscles.
21. Orthotron--A machine used for exercise and testing. This machine controls speed of movement.

22. Passive--Movement performed under the power of the therapist with no muscular contraction by the patient.
23. Repetition--The act of performing again the same movement as done before.
24. Strength--The power of exerting muscular force.
25. Suprapattelar plica--A thickening or fold of the synovial lining located above the pattella on the medial side.
26. Warm-up--A state in which muscle and blood temperature were increased by physical activity.
27. Weight bearing--The allowance of body weight being placed on the extremity or extremities.

CHAPTER II

CASE STUDY

The following was a case study of one 19-year-old male amateur athlete, a quarterback for the University of North Dakota football team. During football practice the subject injured his left knee. This injury was arthroscopically diagnosed as an anterior cruciate ligament tear. This study began immediately at the time of injury.

History

On October 20, 1981 the subject injured his left knee. During football practice he ran a play in which he ran to his left, and then attempted to change direction and cut up field. As he planted his left foot a defensive player struck his right shoulder sending his body rotating to the right while his foot remained firmly planted. As his body was twisting toward the ground his foot remained planted. At this time he felt a severe burning sensation in his left knee. This sensation lasted approximately 30 seconds in duration. A field examination showed no positive findings. He was then taken indoors and was re-examined. At this time he had tenderness above the lateral jointline. Pain could be elicited with both active and passive flexion past 90°. There were no signs

of effusion, or instability at that time. The knee was treated with ice and was wrapped with an elastic bandage. The subject was instructed to return the next morning for further examination.

The following morning his knee was swollen and warm indicating hemarthrosis. His range of motion was limited. By afternoon he was examined by Dr. Briggs, an orthopaedic surgeon. Dr. Briggs aspirated the knee and found a blood tinged fluid. Examination did not show any instability. Following examination, the subject's knee was wrapped with an elastic bandage and placed in a knee immobilizer in a slightly flexed position. The subject was put on crutches with no weight bearing allowed.

He was re-examined the following day at the doctor's office. Dr. Briggs felt his symptoms suggested a probable synovial plica and recommended initial conservative measures with progressive return to activities providing the swelling did not reoccur. The subject was instructed to take aspirin and return to the physician immediately if swelling and discomfort reoccured.

Four days later the subject returned to Dr. Briggs for further evaluation. At this time there was mild swelling and tenderness across the medial joint line. A meniscal tear was suspected. An arthrogram was performed and demonstrated a medial meniscal tear. At this time arthroscopic surgery was scheduled.

Surgery

The arthroscopic diagnosis was a complete tear of the anterior cruciate ligament. The redundant portion was exercised through the arthroscope to prevent impingment in the lateral joint space. There was no attempt to repair the ligament. A medial suprapatellar plica was found and removed. Grade II chondromalica was shaved from the medial femoral condyle. There was no medial meniscus tear and no evidence of joint instability. The knee was sutured, wrapped with an elastic bandage, and placed in a knee immobilizer.

As mentioned earlier, this surgery is one of many that could have been used. This researcher has no intention of implying that it was the best method to use for this condition, nor is it being said that a better method could have been used. It was simply the choice of the attending physician. (Refer to Appendix for the Surgical Report.)

Rehabilitation

Rehabilitation of an anterior cruciate ligament injury begins at the time of injury and continues throughout the subject's life. The goals of the rehabilitation program were to: (1) educate the subject, (2) reinforce stability with exercises based on biomechanical theories, (3) prevent or prolong the subsequent onset of degenerative

changes, (4) minimize risks of reinjury, and (5) reinstate the previous performance level.

Education

From the initial time of injury throughout the rehabilitation period it was the intent of this researcher to provide information and support to the subject. The subject was told in advance what to expect in terms of treatment and rehabilitation procedures. He was given a basic lesson in the anatomy and function of the knee and how this applied to his particular injury. Hughston (30) believed at least 50 percent of the overall results of knee surgery depends upon the rehabilitation effort. By rapidly establishing realistic recovery expectations, the trainer and physician may lessen frustration experienced during the active rehabilitation period.

Exercise Period

There are numerous exercise programs for rehabilitating knee injuries (7, 31-34). The exercise program used for this study was designed by this researcher and was approved by Dr. Briggs. It was designed to specifically meet the needs of the subject involved.

The exercise program was divided into five phases. The progression from one phase to another was based on many factors including approval from Dr. Briggs. These factors will be discussed within each phase. The following is

the rehabilitation program developed for this subject. The specifics of this program will be described later.

Rehabilitation Program

Phase I: Immobilization, Non Weight Bearing Duration: 2nd - 10th day

A. Knee Immobilized
   1. no weight bearing allowed
   2. immobilizer fixed at a position of 30° of flexion

B. Leg Raiers
   1. to maintain muscle tone of thigh musculature

C. Hamstring Blocks
   1. to maintain muscle tone of hamstring group

D. Electric Muscle Stimulation
   1. to maintain muscle tone of knee flexors and extensors

Phase II: Immobilization, Weight Bearing Duration: 2 weeks

A. Knee Immobilized
   1. full weight bearing
   2. immobilizer fixed at a position of 30° of flexion

B. Leg Raisers

1. to maintain muscle tone of thigh musculature

C. Hamstring Blocks

1. to maintain muscle tone of hamstring group

D. Isometrics

1. performed on orthotron
2. to regain strength of the flexors and extensors at positions of 30°, 45°, and 90° of flexion

E. Electric Muscle Stimulation

1. to maintain muscle tone of knee flexors and extensors

F. Cold Whirlpool

1. duration--20 minutes
2. temperature 50°-60° F
3. to control swelling caused by exercise

Phase III: Strength Concentration Duration: 2 weeks

A. Knee is no longer in immobilizer

1. allows full range of motion
2. flexion is not encouraged past the last 15° of extension

B. Isometrics

1. performed on orthotron

2. to regain strength of flexors and extensors at positions of 30°, 45°, and 90° of flexion
3. discontinue when injured leg is at equal strength with other leg

C. Isokinetics

1. performed on orthotron
2. to regain strength of knee flexors and extensors in a full range of motion
3. to regain strength of knee flexors and extensors at varying speeds in a full range of motion
4. extension past the last 15 degrees of flexion is not encouraged.

D. Swimming

1. to regain range of motion
2. to regain neuromuscular control

E. Cold Whirlpool

1. duration 20 minutes
2. temperature 50°-60° F
3. to control swelling caused by exercise

Phase IV: Neuromuscular Control and Endurance Duration: 2 weeks

A. Isokinetics

1. performed on orthotron

2. to regain strength of knee flexors and extensors in a full range of motion
3. to regain strength of knee flexors and extensors at varying speeds in a full range of motion
4. to build endurance

B. Jogging Program
1. to return neuromuscular control
2. to develop both cardiovascular and muscular endurance
3. to develop confidence

C. Cold Whirlpool
1. duration 20 minutes
2. temperature 50°-60° F
3. to control swelling caused by exercise

Phase V: Advanced Neuromuscular Control and Endurance

Duration: 2 weeks

A. Jogging
1. 1 mile
2. to build cardiovascular and muscular endurance
3. to produce a warm-up effect

B. Coordination Drills
1. to develop confidence
2. to develop neuromuscular control
3. to test functional ability

C. Sprints
   1. to develop confidence
   2. to develop neuromuscular control
   3. to test functional ability

D. Isokinetics (3 x per week)
   1. to maintain strength of knee flexors and extensors in a full range of motion
   2. to maintain strengths of knee flexors and extensors at varying speeds in a full range of motion

E. Functional Test (end of 2nd week)
   1. to determine readiness for return to competitive activity

F. Cold Whirlpool
   1. duration 20 minutes
   2. temperature 50°-60° F
   3. to control swelling caused by exercise

Description of Rehabilitation Phases

Phase I: Immobilization, Non Weight Bearing

Immediately after surgery the subject was placed in a knee immobilizer with his knee flexed to a position of 30°. He was given crutches and instructed not to put any weight on his injured leg.

Fig. 1. Patient shown in Knee Immobilizer

The immobilizer was flexed to prevent the knee from extending past 30°. It was Dr. Briggs' opinion that an isolated anterior-cruciate ligament tear probably does not exist when the knee is injured in a hyper-extended position. Therefore, it was likely that the secondary stabilizers, the posterior lateral portion of the capsule, had stretched. By holding the knee from extending past 30°, the physician hopes to facilitate healing of the secondary stabilizers (35).

With the practice of immobilization came the problem of muscle atrophy. When a muscle is not permitted to contract through a full range of motion it weakens and decreases in size. This was monitored by measuring the circumference of the thigh.

The following exercises were done to maintain muscle tone of the thigh.

Four types of leg raisers were started the second day after surgery. At first they were done with no means of resistance. When the subject progressed to 3 sets of 10 repetitions, additional resistance in the form of sandbag weights were used and increased as the subject progressed. The following is a description of the four types of leg-raisers used in this study. All exercises were performed once daily.

The subject sat with his back against a wall. The uninjured leg is bent at the knee while the bottom of the foot was placed flat on the table, with his heel resting as close as possible to his body. The injured leg is contracted isometrically, the ankle is pulled into dorsal flexion. At this time the subject raised his leg six inches and held this position for six seconds. He then rested for 2 seconds and then repeated for 10 repetitions. He did 3 sets of 10 repetitions, resting one minute between each set of 10. The position for flexion leg raisers is shown in Figure 2. Figures 3, 4, and 5 show how the remaining leg raisers of extension, abduction and adduction were done. They were all performed by contracting the leg and dorsal flexing the ankle. All exercises were performed using the same program as the flexion leg raisers.

Fig. 2. Subject showing position for flexion.

Fig. 3. Subject showing position for extension leg raiser.

Fig. 4. Subject showing position for abduction leg raiser.

Fig. 5. Subject showing position for adduction leg raiser.

Table 1 shows the progression of resistance (sandbag weights) used for leg raiser exercise. The practice of increasing resistance was based on the subject's maximum tolerance without pain.

Hamstring blocks were also started the second day after surgery. These were done to prevent atrophy of the hamstring group. To perform hamstring blocks the subject sat with his back against a wall. An object was placed beneath his knee to prevent extension. The subject was then instructed to press his heel of the injured leg into the table for six seconds. He was then allowed a two second rest. He repeated this procedure for ten repetitions. He was then given a one minute rest. This procedure was repeated three times. The position used for hamstring blocks is shown in Figure 6.

Fig. 6. Subject demonstrates proper position for hamstring blocks.

TABLE 1

WEIGH LOAD INCREASE FOR LEG RAISER EXERCISES (in pounds)

Resistance in lbs.

	Phase I									
Day	1	2	3	4	5	6	7	8	9	10
Flexion	0	0	0	2½	2½	2½	2½	5	5	5
Extension	0	0	7½	7½	10	10	10	10	12½	12½
Abduction	0	0	7½	7½	10	10	10	12½	12½	12½
Adduction	0	0	5	5	7½	7½	10	12½	12½	12½

	Phase II											
Day	11	12	13	14	15	16	17	18	19	20	21	22
Flexion	5	5	5	7½	7½	7½	7½	7½	7½	10	10	10
Extension	12½	15	15	15	17½	20	20	20	20	20	20	20
Abduction	12½	15	15	17½	17½	20	20	20	20	20	20	20
Adduction	12½	12½	15	15	17½	17½	20	20	20	20	20	20

Electric muscle stimulation was given to help maintain muscle tone of the knee flexors and extensors. The stimulator alternately contracted the hamstring and quadricep muscle groups. Treatments were given once daily and each treatment lasted for fourteen minutes. Figure 7 shows the placement of the electric stimulation pads.

Fig. 7. Electric stimulation treatment demonstrating placement of stimulation pads.

At the end of Phase I the subject's sutures were removed. He was then gradually allowed to bear weight and he progressed to full walking in three days.

The initial circumference after surgery showed some atrophy. During the end of Phase I the thigh circumference increased and remained at a constant level relatively close to that of his uninjured leg throughout the rest of the rehabilitation program. This is shown in Table 2.

TABLE 2

MEASURE OF THIGH CIRCUMFERENCE AT THREE AREAS ABOVE THE PATELLA

	Inches above proximal end of patella	Phase I		Phase II		Phase III		Phase IV	Phase V	Re-injury	Phase III	Phase IV	Phase V
Right thigh (uninjured) circumference (in inches)	2"	17.50	17.50	17.75	17.25	17.25	17.50	17.50	18.50	X	17.75	18.00	17.50
	5"	21.50	21.75	21.50	20.75	21.25	21.25	21.00	22.00	X	21.25	21.50	21.25
	8"	23.50	24.00	24.00	23.50	23.75	23.75	23.50	24.00	X	23.75	24.00	23.75
Left thigh (injured) circumference (in inches)	2"	17.00	17.00	17.50	17.00	16.75	17.00	17.25	17.25	X	17.50	17.25	17.25
	5"	20.25	19.50	21.00	20.00	19.75	20.75	20.50	21.50	X	21.00	20.25	20.75
	8"	23.00	22.75	23.50	23.50	22.50	23.00	23.25	23.75	X	23.25	23.25	23.25

Note: All measurements were taken before exercise.

Phase II. Immobilization with Full Weight Bearing

This stage was defined by the removal of the subject's crutches. The knee remained in the immobilizer at a position of 30°.

Due to the fact that the knee was still immobilized, all exercises of Phase I were continued.

In addition to the Phase I exercise, a new exercise was started. The subject was removed from his immobilizer to perform isometric contraction of his hamstring muscles. There was no weight placed on the injured extremity while the immobilizer was off. The subject was placed on the orthotron* with his leg being fixed at a specific angle. Like the hamstring blocks, the subject attempted to press downward with the heel of his foot. This isometric contraction was held for six seconds with a two second rest interval between repetitions. Three sets of ten repetitions were performed at each of three different angles, 30°, 45°, and 90° of flexion.

The orthotron unit provides a feedback system that measures the amount of foot pounds being exerted by the subject. This feedback resembles a speedometer in that the needle moves across the face of a calibrated dial.

This feedback system was used to monitor the subject's progress. The subject's uninjured leg was also tested as a method of comparison. The uninjured leg was

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*Lumex, Inc., 1005 Spence St., Bay Shore, NY.

Fig. 8. Subject demonstrates isometric contraction at a position of 45°.

Fig. 9. Orthotron feedback system calibrated in foot pounds.

not placed on an exercise program. Table 3 demonstrates the subject's progress for isometric contractions.

A cold whirlpool of 20 minutes duration was used to control swelling caused by exercise. The water temperature ranged from 50 to 60 degrees farenheit. Swelling was never a problem during rehabilitation program.

Phase III. Strength Concentration

This stage was begun with the removal of the knee immobilizer. Full weight bearing was allowed immediately. With the removal of the immobilizer, the patient was allowed to move throughout a full range of motion although he was encouraged to work slightly short of full extension. The purpose for limiting the last degrees of extension was so that the secondary stabilizers would not be stressed (35).

The subject continued with his isometric exercises from Phase II until both of his legs were of equal strength. This occurred one week into Phase III. At that time the isometrics were discontinued.

Isokinetic exercises were introduced at the beginning of stage III. This exercise was performed on the orthotron. The orthotron was used at six different levels of resistance. Table 4 shows the complete Isokenetic orthotron program.

The isokinetic were used to regain strength through a full range of motion at varying speeds. Isokinetics

TABLE 3

MEASURE OF ISOMETRIC CONTRACTIONS

	Orthotron Angle	Phase I		Phase II	Second Injury	Phase III		Phase IV	Phase V
Right (uninjured) leg (in foot lbs)	30°Q	150	X	X	220	305	315	310	345
	30°H	175	X	X	190	195	225	205	215
	45°Q	240	X	X	245	300	270	300	290
	45°H	190	X	X	190	230	220	200	245
	90°Q	275	X	X	250	190	180	220	215
	90°H	150	X	X	170	200	230	215	225
Left (injured) leg (in foot lbs)	30°Q	100	175	175	305	345	415	375	450
	30°H	75	175	165	200	195	215	220	215
	45°Q	155	250	275	355	295	305	350	360
	45°H	35	145	175	200	225	245	250	255
	90°Q	20	75	305	325	175	190	250	250
	90°H	10	40	155	185	175	210	275	250

Key: Q = Quadriceps
H = Hamstrings
X = No reading taken

TABLE 4

ISOKINETIC ORTHOTRON PROGRAM
(Program is done Monday through Friday)

	Resistance Setting of Orthotron					
	4	6	8	3	5	7
Number of Repetitions	5x10	5x10	5x10	3x10	3x10	3x10

were chosen over isotonic exercises for two reasons. First, isokinetics will stress the extremity to its maximum level at all ranges of motion, while isotonics only provide maximum stress at the joint's strongest position. Secondly, by using the orthotron the subject's strength controls his own level of resistance. He was not able to overestimate his capabilities. This lessened the potential for injury during the rehabilitation program.

Once again, extension past the last 15° of flexion is not encouraged. It was not the purpose of this rehabilitation program to put unnecessary stress on the posterior capsule of the knee.

The feedback system of the orthotron machine allowed monitoring the progress of the subject. This is shown in Table 5. To measure progress the injured left leg was compared to the uninjured right leg.

A swimming program was instituted at the beginning of Stage III. The subject swam laps of any stroke of his choice for a fifteen minute period. Swimming was incorporated into this rehabilitation program to regain full range of motion, basic neuromuscular control, and cardiovascular fitness.

After all exercises of Phase III were completed, the subject submerged his leg in a cold whirlpool for a period of 20 minutes, as a preventive measure against swelling. All exercises of Phase I were executed once per day, five days a week for two weeks.

TABLE 5

MEASURE OF ISOKINETIC MAXIMUM OUTPUT

Orthotron Levels of Resistance (in foot lbs)		Phase III		Phase IV	Phase V	Re-injury	Phase III		Phase IV	Phase V
	Right Leg									
	3Q	250	X	250	260	X	290	315	310	310
	3H	200	X	200	215	X	225	215	225	225
	5Q	225	X	200	220	X	210	200	225	215
	5H	185	X	175	200	X	190	175	180	200
	7Q	200	X	175	175	X	175	150	175	175
	7H	175	X	150	150	X	140	125	170	150
	Left Leg									
	3Q	X	265	225	270	X	275	255	280	310
	3H	X	190	205	225	X	205	180	225	250
	5Q	X	190	175	205	X	190	190	200	225
	5H	X	180	180	190	X	175	175	175	205
	7Q	X	175	165	170	X	150	150	150	175
	7H	X	125	150	160	X	150	150	150	160

Key: Q = Quadriceps
H = Hamstrings
X = No reading taken

Phase IV. Advanced Neuromuscular Control and Endurance

This stage was reached when the subject's isokinetic readings for his injured extremity were 90 percent of that of his uninjured leg (see Table 5). At that time the subject began the functional portion of this rehabilitation program.

The isokinetic program of Phase III was continued throughout Phase IV. In addition to this another orthotron exercise was added. The orthotron was set at minimal resistance. The subject did as many repetitions as he could within one, two minute interval. This was done to enhance muscular endurance.

After completing the orthotron program the subject began the jogging program. The jogging program is described in Table 6.

Once both the orthotron and jogging programs were done the subject submerged his leg in a preventive cold whirlpool. The purpose of Stage IV was to build confidence and strength while increasing neuromuscular control, endurance, and cardiovascular fitness.

Phase V. Advanced Neuromuscular Control and Endurance

After successful completion of Stage IV the subject's orthotron readings were all above 100 percent efficiency as compared to the uninjured leg (see Table 5). Stage V was conducted to develop the confidence, endurance

TABLE 6

JOGGING PROGRAM
(used on indoor track where 1 lap = 1/12 mile)

Day		Laps
1	Jog straights walk curves	6
2	Jog straights walk curves	7
3	Jog straights walk curves	8
4	Jog straights walk curves	9
5	Jog straight walk curves	10
6	Jog whole track	6
7	Jog whole track	8
8	Jog whole track	10
9	Jog whole track	10
10	Jog whole track	10

Note: When subject jogged whole track he went both clockwise and counterclockwise to prevent stress from using a small track.

and neuromuscular control necessary to return to competitive athletics.

The orthotron isokinetic program was continued at a rate of three times per week to maintain strength. In addition, a vigorous running program was developed.

The running program began with a quick one mile jog, after which coordination drills were begun. All drills were started at a slow comfortable pace. As the subject's confidence developed, the pace of the drills was progressively increased until full speed was attained. The drills emphasized changing directions, running backwards, stopping short, and changing speeds. These drills were followed by sprints of forty yards. At the end of each workout a preventive cold whirlpool was taken. Workouts were done five times per week, Monday through Friday.

Stage V was interrupted when the subject engaged in an activity outside of his rehabilitation program and injured his left knee. An arthroscopy was performed and it demonstrated no significant damage with only a slight area of tearing to an old fragment of remains of his anterior cruciate ligament. Dr. Briggs did not feel that this fragment would contribute to the stability of this subject's knee. The subject returned to this rehabilitation program at Stage II and returned to Stage V in four weeks. At the end of Stage V he passed a functional test. This test is explained in Table 7.

TABLE 7

FUNCTIONAL TEST FOR ANTERIOR CRUCIATE INSUFFICIENCY

1. Jog 1 mile (within 6 minutes and 30 seconds)
2. Jog criss-cross pattern around markers while touching floor next to marker.

    a) 3 repetitions forward touching R hand rest 1 min.

    b) 3 repetitions forward touching L hand rest 1 min.

    c) 3 repetitions backward touching R hand rest 1 min.

    d) 3 repetitions backward touching L hand rest 1 min.

3. Run 40 yards at full speed, walk 40 yards

    a) repeat 5 times.

To evaluate this functional test the subject must be watched closely. The examiner looks for the following:

1. Any sign of limping
2. Any sign of compensation
3. Any sign of hesitation.

If any of the following have occurred the subject fails the test. The subject must perform all drills at maximum speed to fully pass the test.

Protective Bracing

Bracing is becoming a popular method of management in returning an athlete to competitive athletics. The brace that has been found most effective is the Lenox Hill Derotation Brace (34, 35). Whether the brace will actually do what is claimed is at this time a very controversial subject. A Lenox Hill Derotational brace was prescribed for the subject of this study. It should be worn at all times when the subject participates in athletic activities. (The brace should never be used in place of an on-going rehabilitation program (see Figures 10 and 11).

On Going Rehabilitation

It is important to maintain optimal strength when one has an anterior cruciate insufficiency. A discussion with the subject as to the importance of maintaining his physical condition was conducted. He was placed on a mild isokinetic program shown in Table 8.

Fig. 10. Front view of Lenox Hill Derotation brace.

Fig. 11. Back view of Lenox Hill Derotation brace.

TABLE 8

ISOKINETIC MAINTENANCE PROGRAM
(3x per week)
ORTHOTRON SETTINGS

	3	5	7
Repetitions	3x10	3x10	3x10

A discussion dealing with ongoing pathologies was also conducted with the subject. He was informed of his statistical chances of returning to competition along with the possibility of chronic deterioration associated with anterior cruciate injuries.

CHAPTER III

DISCUSSION AND CONCLUSION

Successful rehabilitation is best achieved when the physician, trainer, and athlete work as a team. The subject's personality and individual goals provided the motivation and discipline necessary to complete this rehabilitation program.

This rehabilitation program seemed to produce excellent results on the surface. The subject's muscular strength was greater for his injured extremity. His ability to function in coordination and endurance drills was also very satisfactory. With this in mind one might have asked, if muscular strength, endurance, and coordination were sufficient enough factors to have maintained good function to a knee that had an anterior cruciate insufficiency, or are these factors simply prolonging time before chronic deterioration sets in and additional pathologies develop.

The subject's second injury occurred when he participated in an activity outside of this researcher's control. Although the subject was not at that time cleared for activity, he theoretically should not have experienced any problem with what he was doing. Therefore this researcher

was not convinced that the subjects knee would withstand future stress without developing additional pathologies. A long term follow-up study would demonstrate the subject's ability to maintain normal function of his knee joint.

The results of this study were acquired by the evaluation of one individual. Programs similar to this one should be tested on many subjects before any conclusions should be drawn. It would have been scientifically unsound to draw any conclusions from just one example.

One should consider the patient's individual needs when developing a rehabilitation program. This program was designed to fit the specific needs of this subject. This rehabilitation program should be used as a general guideline for physicians, athletic trainers, physical therapists, and athletes who have the opportunity of rehabilitating an anterior cruciate tear.

Summary

A review of the anatomical structure, mechanism of injury, treatment, surgery, and follow-up studies of anterior cruciate tear was presented. In addition a case study depicting the mechanism of injury, treatment, surgery and the results of a specifically designed rehabilitation program were also presented.

APPENDICES

APPENDIX I

SURGICAL REPORTS

STOCK, NEIL

PREOPERATIVE DIAGNOSIS: Internal derangement of left knee with probable medial meniscal tear.

POSTOPERATIVE DIAGNOSIS: Internal derangement of left knee with:
1. Complete tear of anterior cruciate ligament.
2. Suprapatellar plica.
3. Chrondromalacia of the medial femoral condyle.

OPERATION: 10-29-81 Left knee examination under anesthesia, arthroscopy, arthroscopic excision of redundant portion of anterior cruciate ligament impinging in the lateral joint space, shaving of medial femoral condylar chondromalacia, removal of suprapatella pliac.

SURGEON: B. T. Briggs, M.D.

ANESTHESIA: General

ASSISTANT: Mr. Mueller, OA

Following satisfactory preoperative medical assessment and with clinical examination and arthrographic review confirming the anticipation for a medial meniscal tear the patient was brought to the OR and general anesthesia induced. Examination of the right lower extremity confirmed 2 to 3 mm. of Lachmann's laxity, no evidence of additional instability. The left knee examination demonstrated a moderate degree of residual swelling subsequent to the arthrogram, a definite sensation of fluid and air within the knee and 3 to 4 mm. of Lachmann's laxity negative straight varus valgus laxity and negative pivot shift. The left lower extremity was elevated, shaved scrubbed, prepped and draped in the usual fashion. The arthroscope was introduced through the lateral suprapatellar approach where the retropatellar surface, medial and lateral gutters, suprapatellar pouch were thoroughly visualized and the only demonstrable abnormality being that of an area of hemorrhage involving a midportion of the medial suprapatellar plica. The arthroscope was reintroduced through the lateral approach and utilizing a probe medially the notch was demonstrated with a hemorrhagic torn anterior cruciate ligament. A small portion of the posterior lateral band appeared to remain anatomically intact, but the remainder demonstrated fraying appearing to have torn at a junction of the proximal 1/3rd and distal 2/3rds and with insufficient bulk or length of ligament to appear to be satisfactory for surgical repair. The arthroscope was introduced into the medial compartment where the medial meniscus was thoroughly probed over its superior and inferior surfaces but no evidence of meniscal tear including the posterior medial portion where this was directly visualized utilizing the needle scope and no abnormalities ascertained. There was an

CONTINUED ON NEXT PAGE

area of approximately 1 cm. by 8 mm. of grade II chondromalacia which was shaved utilizing the Dyonic shaver. The lateral compartment was attempted to be visualized in figure 4 position, however, this was not possible since a portion of the redundant anterior cruciate ligament tear engaged the lateral joint space. The anterior cruciate ligament was therefore shaved utilizing the Dyonic shaver and with the redundant portion excised so that no impingement in the joint space was possible. The lateral meniscus was readily visualized and probed over its superior and inferior surface but no evidence of abnormality ascertained. The Dyonic shaver was additional utilized for removal of the suprapatellar plica. The knee was thoroughly irrigated. Wounds were closed with 4-0 subcuticular wire and steri-strips applied. A sterile compression dressing applied. The knee again placed into a knee immobilizer with the knee flexed to a 30 degree position. The patient tolerated the procedure well and returned to PAR in satisfactory condition.

B T. Briggs, M.D. 10-29-81
Jeg 10-30-81 (#3)

STOCK, NEIL

PREOPERATIVE DIAGNOSIS: Internal derangement left knee. Status post anterior cruciate ligament tear and with probable medial meniscal tear.

POSTOPERATIVE DIAGNOSIS: Old anterior cruciate ligament tear of left knee with recent hemorrhage of remaining portion of anterior cruciate ligament, grade II anterior cruciate ligament tear and area of chondromalacia of the medial femoral condyle.

OPERATION: 2-4-82 left knee examination under anesthesia, arthroscopy, arthroscopic shaving of grade 2 medial femoral chondromalacia.

SURGEON: R. T. Briggs, M.D.

ANESTHESIA: General

ASSISTANT: Rick Woodbeck, OA.

Following satisfactory preoperative medical assessment and with clinic examination demonstrating the presence of acute knee symptoms status post previous anterior cruciate ligament tear and with probable medial meniscal tear and hemarthrosis the patient was felt to be satisfactory candidate for arthroscopic evaluation. Following thoroughly preoperative review and discussion the patient was brought to the OR and general anesthesia induced. Examination of the right lower extremity demonstrated normal findings. Left knee examination demonstrated full range of motion. 2 to 3 mm. of Lachmann's laxity, 3 to 4 mm. of anterior drawer laxity, negative pivot shift and mild anterior lateral rotatory laxity. McMurray's test was negative. The left knee was elevated, shaved, scrubbed, prepped and draped in the usual fashion. utilizing the previous arthroscopic portal site the arthroscopic sheath was introduced and the knee irrigated for a moderate degreee of hemarthrosis. Direct visualization of the suprapatellar pouch, medial and lateral gutters and retropatellar surface failed to demonstrate any definite abnormalities. With reintroduction of the arthroscope through the lateral portal direct visualization and the notch and probing through a medial approach confirmed the presence of acute area of hemorrhage in the midsubstance portion of the remaining anterior cruciate ligament. This appeared to represent a grade 2 injury as there was no discontinuity of fibers and still some residual taughtness to this structure. The arthroscope was introduced into the medial compartment where the entire medial meniscus was visualized, probed over its superior and inferior surfaces and no evidence of abnormality or tear ascertained. There was no area of hemorrhage. Direct visualization of the medial femoral condyle demonstrated an area of grade II chondromalacia of the medial femoral condyle adjacent to the tibial spine and over an area of 1½ cm. in length and 5 mm. in width. This area was shaved and smoothed so that no rough edges or frayed debris remained. The arthroscope was re-introduced into the lateral compartment and utilizing direct probing the entire lateral

CONTINUED ON NEXT PAGE

meniscus was readily visualized with no abnormalities ascertained. The knee was irrigated, closed with 4-0 Ethilon, sterile compression dressing applied. The patient tolerated the procedure well and returned to PAR in satisfactory condition. The patient received 1 gram of Keflin IV intraoperatively.

B. T. Briggs, M.D. 2-4-82
Jeg 2-5-82

cc UND Training Staff

University of North Dakota
Grand Forks, North Dakota 58201

APPENDIX II

PHYSICIAN'S PROGRESS REPORTS

THE ORTHOPAEDIC CLINIC, P.C.
960 South Columbia Road
GRAND FORKS, NORTH DAKOTA 58201

-53(22)48259

SE NO. NAME Neil H. Stock (FA: Harry) Address 404A West Hall, UND
Grand Forks, ND 58201

13 M F S M W D Occupation Ref. By

01-21-63
nily History

Date	
-22-81	PATIENT: Neil H. Stock (FA: Harry) 404A West Hall, UND Grand Forks, ND 58201 BIRTHDATE: 01-21-63 AGE: 18 DATE OF EXAMINATION: October 22, 1981 This 18-year-old male is seen today on referral from UND football team and for additional assessment and evaluation of left knee status subsequent to examination at the training room last p.m. demonstrating acute left knee effusion and anterior medial joint tenderness subsequent to a compression rotation type injury the day previously but with no definite snap, pop or click and no previous history of knee symptoms. ON EXAMINATION yesterday, Neil demonstrated sufficient localized anterior medial tenderness and effusion to warrant knee aspiration where under strict sterile precautions, the left knee was aspirated for 35 cc's of slightly blood-tinged fluid. Patient was compressed, placed on a program of crutch ambulation and seen in the clinic today for additional evaluation and x-rays. Since aspiration last p.m., Neil has had marked improvement in his symptoms. PHYSICAL EXAMINATION today demonstrates minimal effusion, mild tenderness remaining over the anteromedial joint line and medial femoral condyle at the joint surface. Knee range of motion 0 to 110 degrees. No evidence of ligamentous laxity. No apparent patellofemoral signs and McMurray's test with definite palpable snapping sensation over the anteromedial femoral condyle and not over the joint space. This appears to clinically represent an anteromedial plica band and not likely anticipated to represent a meniscal tear. These findings have also been reviewed and discussed with Tammy (UND Trainer) present with Neil today. IMPRESSION: Internal derangement left knee with probable medial plica. I have discussed at length with Mr. Stock today that though I cannot be absolutely sure he does not have a cartilage tear, his seems unlikely since he only had a slightly bloody effusion and his tenderness and snapping today are in the classic distribution for a medial plica rather than a meniscal tear. I have discussed at length the nature of this problem and the recommendation for initial conservative measures with compression utilizing a knee sleeve, progressive ambulation as able provided swelling does not occur, continued use of a program of aspirin and reevaluation immediately should recurrent swelling or discomfort occur. If patient were to have recurrent effusion, I would wish to have him undergo aspiration and arthrogram to be sure of the diagnosis and if any major indication for meniscal tear, one would consider the possibility of arthroscopic examination. Brian T. Briggs, M.D.

THE ORTHOPAEDIC CLINIC P.C.
960 South Columbia Road
Grand Forks, North Dakota 58201

NO. 6-53(22)48359 SHEET NO. 2

Neil H. Stock (FA: Harry) ADDRESS 406 A West Hall, UND GF,ND 58201

Date

-26-81 On return today, Neil demonstrates improvement in function with decreased swelling and mild discomfort, able to ambulate with slight stiff legged gait demonstrating range of motion 0 to 110 degrees. There continues to be tenderness over the medial joint line and a moderate effusion. With these findings, I have again discussed with Neil and recommended for him to proceed with arthrogram to rule out the possibility of occult meniscal tear. Will see back following this for further discussion.

BTB/ba
cc: UND Training Staff

0-27-81 See arthrogram report by Dr. Rigby. kja

27-81 Neil is seen today following his arthrogram and for additional discussion. He has continued to have swelling and discomfort since our last evaluation.

The arthrogram has been reviewed and I concur that this demonstrates an apparent medial meniscal tear.

Will progress with arthroscopy and have discussed and recommended this with the patient today. Complete dictation to United Hospital.

BTB/ba
cc: UND Training Staff

0-29-81 United operative report

DIAGNOSIS: Internal derangement of left knee with:

1. Complete tear of anterior cruciate ligament.
2. Suprapatellar plica.
3. Chondromalacia of the medial femoral condyle.

OPERATION: Left knee examination under anesthesia, arthroscopy, arthroscopic excision of redundant portion of anterior cruciate ligament impinging in the lateral joint space, shaving of medial femoral condylar chondromalacia, removal of suprapatella plica. BTB/kja

HOSPITALIZED AT UNITED HOSPITAL
FROM 10-28-81 TO 10-30-81

INSURANCE CLAIM SUBMITTED

3-81

THE ORTHOPAEDIC CLINIC, P.C.
960 South Columbia Road
GRAND FORKS, NORTH DAKOTA 58201

NO. 6-53(22)-48359 SHEET NO. 3

Neil H. Stock (Ja: Harry) ADDRESS 406 A West Hall, UND GF, ND 5

Date

1wk, 4 days p.o.

Patient is seen following his knee surgery, demonstrates excellent overall appearance. Wound is satisfactory, sutures removed and steri-strips applied. Will continue with immobilization, utilizing the knee immobilizer, a strong program of strengthening and see back at 3 to 4 weeks postop for reevaluation.

BTB/ba
cc: UND Training Staff

On return today, Mr. Stock demonstrates satisfactory overall appearance with minimal quadriceps atrophy, good range of motion, 2 to 3 mm of Lachman's and anterior Drawer, but no gross evidence of anterolateral rotatory laxity and negative pivot shift.

I have discussed with the patient his continued program for fitting of Lennox-Hill orthosis, continue with his strengthening program, discontinue his immobilizer and continue to avoid full extension beyond -5 to 10 degrees. Will wish to have him fit with the knee orthosis and see back in 3 to 4 weeks time.

BTB/mmg
CC: UND Training Staff

1 4 1981 Rescheduled to 12/17 cs

1 7 1981 On return today Mr. Stock indicates that he has been fitted with his orthosis and has been doing well.

Indeed his clinical examination remains excellent with 1 to 2 mm of anterior cruciate laxity and no pivot shift. I must commend the excellent rehabilitative program which Mr. Stock has been instructed on and obviously carried out very faithfully. I am pleased with his overall function and have encouraged him regarding his continuing strengthening and increased function program.

Will wish to see back following his Christmas break for further assessment prior to very vigorous physical endeavors.

BTB/wk
cc: UND Training Staff

THE ORTHOPAEDIC CLINIC, P.C.
960 South Columbia Road
GRAND FORKS, NORTH DAKOTA 58201

NO. 6-53(22)48259 SHEET NO. 4

Neil H. Stock (FA: Harry) ADDRESS 404 A West Hall, UND GF,ND 58201

Date

28-82 Neil injured his left knee yesterday while running a "T-test for a T". This test involves backpedaling around several pylons and then "shuffling" around the pylons in a lateral motion. During this lateral movement he apparently was dragging his left foot somewhat and felt a pop on the lateral side of his knee. He subsequently experienced pain along the medial aspect of the knee. The knee was iced, but the next day was found to be somewhat swollen and warm. He apparently has been very active in UND sports since his arthroscopy and the day prior to his recent injury he was running 40 yard sprints. At this time he denies any locking, grinding or popping. His trainer felt that she could elicit a McMurray's on the lateral side of the knee after his injury yesterday. His pain today, however, is on the medial aspect of the knee.

PHYSICAL EXAMINATION found that his range of motion was from 0 to approximately 100 degrees. The knee was somewhat warm in comparison to the opposite side and also somewhat swollen. I was unable to detect an effusion. The circumference measured at the superior pole of the patella was symmetrical with the opposite side, however, 10 cm proximal from this point the left thigh measured 1.5 cm smaller than the right. Palpation of the medial aspect did not reveal any particular point tenderness although he seemed to be generally tender in the area of the origin of the medial collateral ligament. There was a definite stop on valgus stress testing and the collateral ligament could be palpated. With a more vigorous valgus stress he had some pain. The lateral collateral ligament was intact. The Lachman's showed only approximately 4 or 5 mm of laxity. The pivot shift was negative. I was unable to reproduce a positive McMurray's today possibily because of his swelling and lack of flexion beyond 100 degrees.

IMPRESSION: 1. Probable Grade I medial collateral ligament strain.

RECOMMENDATION: I have asked that Neil apply a knee immobilizer over his neoprene knee sleeve. He will return to The Orthopaedic Clinic to be seen by Dr. Briggs in 1 week. Perhaps at that time the swelling will have decreased enough to perform the McMurray's test again. Arthroscopy may be indicated if the test is found to be positive. In the mean time he will continue his quadriceps and hamstring strengthening exercises.

RAJ/ke
cc: UND Training Staff

03 1982 Patient returns following Dr. Johnson's review indicating that he has continued to have symptoms and indeed on physical examination appears to have a possible meniscal tear with mild joint line tenderness and pain with attempt at McMurray's test and residual findings of anterior cruciate laxity without pivot shift. Sterile aspiration of the left knee has demonstrated 4 to 5 cc of bloody fluid.

With the finding of hemarthrosis, a previous presence of an anterior cruciate lesion and the likely presence of a medial meniscal tear, I have discussed with patient the possible alternatives and recommendation for definitive arthroscopic review.

THE ORTHOPAEDIC CLINIC, P.C.
960 South Columbia Road
GRAND FORKS, NORTH DAKOTA 58201

NO. 6-53(22)-48259 SHEET NO. 5

Neil H. Stock (FA: Harry) ADDRESS 404 A West Hall, UND, GF, ND 58201

Date

(con't)

)3-82 This has been discussed in detail. Patient wishes to proceed and complete dictation to United Hospital done.

Brian T. Briggs, M.D.

BTB:dfp
cc: UND Training Staff

?--4-82 UNITED OPERATIVE REPORT:

DIAGNOSIS: Old anterior cruciate ligament tear of left knee with recent hemorrhage of remaining portion of anterior cruciate ligament, grade II anterior cruciate ligament tear and area of chondromalacia of the medial femoral condyle.

OPERATION: Left knee examination under anesthesia, arthroscopy, arthroscopic shaving of grade 2 medial femoral chondromalacia. BTB/kja

[illegible] 2-3-82 to 2-5-82

3 1 1982 1 wk p.o.

On return Mr. Stock continues to demonstrate satisfactory status with mild swelling remaining. The wounds are healing satisfactorily, sutures removed and steri-strips applied.

Will continue with progressive post-operative program and plan to see back in 4 to 6 weeks time at the university clinic.

BTB/wk
cc: UND Training Staff

REFERENCES

1. Paulos, L.; Noyes, F.; and Malek, M. "A Practical Guide to the Initial Evaluation and Treatment of Knee Ligament Injuries." The Journal of Trauma 20 (1980): 498-506.

2. McDaniel, J., and Dameron, T. "Untreated Ruptures of the Anterior Cruciate Ligament." The Journal of Bone and Joint Surgery 62-A (1980): 696-704.

3. Welsh, P. "Knee Joint Structure and Function." Clinical Orthopaedics and Related Research 147 (1980): 7-14.

4. Gray, H. Anatomy of the Human Body. 29th ed. American Edition. Edited by Charles May Coss. Philadelphia: Lea and Febiger, 1973.

5. Marshall, J. L.; Rubin, R. M.; Wang, J. B.; Fetta, J. F.; and Arnocaky, S. P. "The Anterior Cruciate Ligament--The Diagnosis and Treatment of Its Injuries and Their Serious Prognostic Implications." Orthopaedic Review 7 (1978): 35-45.

6. Kennedy, J. C.; Weindberh, H. W.; and Wilson, A. S. "The Anatomical and Functions of the Anterior Cruciate Ligament." The Journal of Bone and Joint Surgery 53-A (1971): 1561-70.

7. O'Donoghue, D. Treatment of Injuries to Athletes. 3rd ed. Philadelphia: W. B. Saunders, 1976.

8. Klafs, C. E., and Arnheim, D. D. Modern Principles of Athletic Training. St. Louis, Missouri: C. V. Mosby, 1973.

9. McLeod, W. D.; Moschi, A.; Andrews, J. R.; and Hughston, J. C. "Tibial Plateau Topography." American Journal of Sports Medicine 5 (1977): 13-18.

10. Hughston, J. C.; Andrews, J. R.; Cross, M. J.; and Masoni, A. "Classification of Knee Ligament Instabilities. Part I. The Medial Compartment and Cruciate Ligaments." The Journal of Bone and Joint Surgery 58-A (1976): 159-72.

11. Hughston, J. C.; Andrews, J. R.; Cross, M. J.; and Moschi, A. "Classification of Knee Ligament Instabilities. Part II. The Lateral Compartment.

The Journal of Bone and Joint Surgery 58-A (1976): 173-79.

12. Ellison, A. E. "Knee Injuries." Clinical Symposia--CIRA. 2d (1977): 18-37.

13. Youmains, W. T. "The So-called 'Isolated' Anterior Cruciate Ligament Tear or Anterior Cruciate Ligament Syndrome: A Report of 32 Cases With Some Observations on Treatment and Its Effect on Results." The American Journal of Sports Medicine 5 (1977): 144-53.

14. Reider, B., and Marshall, J. L. "The Anterior Cruciate Guardian of the Meniscus." Orthopaedic Review 8 (1979): 83-87.

15. Arnold, J. A.; Coker, T. P.; Heaton, L. M.; Park, J. P.; and Harris, W. P. "Natural History of Anterior Cruciate Tears." The American Journal of Sports Medicine 7 (1979): 305-13.

16. Maids, D. B.; Andrews, J. G.; and Stonecipher, T. "Medial and Anterior-Posterior Ligament Stability of the Human Knee Measured with a Stress Apparatus." The American Journal of Sports Medicine 5 (1977): 144-53.

17. Norwood, L. A., and Cross, M. J. "Anterior Cruciate Ligament: Functional Anatomy of its Bundles in Rotary Instabilities." The American Journal of Sports Medicine 7 (1979): 23-26.

18. Torg, J. S.; Conrad, W.; and Kalen, V. "Clinical diagnosis of Anterior Cruciate Ligament Instability in the Athlete." The American Journal of Sports Medicine 4 (1976): 84-91.

19. Slocum, D. B.; James, S. L.; Larson, R. L.; and Singer, K. M. "Clinical Test for Anterolateral Rotary Instability of the Knee." Clinical Orthopaedics 118 (1976): 63-69.

20. Feagin, J. A., Jr. "The Syndrome of the Torn Anterior Cruciate Ligament." Orthopaedic Clinics of North America 10 (1979): 81-89.

21. James, S. L. "Biomechanics of Knee Ligament Reconstruction." Clinical Orthopaedics and Related Research 146 (1980): 90-101.

22. Groves, E. W. H. "Operation for Repair of the Crucial Ligaments." Clinical Orthopaedics and Related Research 147 (1980): 4-6.

23. Jones, K. G. "Results of Use of the Central One Third of the Patellar Ligament to Compensate for Anterior Cruciate Ligament Deficiency." Clinical Orthopaedics and Related Research 147 (1980): 39-44.

24. Fox, J. M.; Blazina, M. E.; Del Pizzo, M.; Ivey, M. F.; and Broukhim, B. "Extra-Articular Stabilization of the Knee Joint for Anterior Instability." Clinical Orthopaedics and Related Research 147 (1980): 56-60.

25. Marshall, J. L., and Rubin, R. M. "Knee Ligament Injuries: A Diagnostic and Therapeutic Approach." Orthopaedic Clinics in North America 8 (1977): 641-65.

26. Noyes, F. R., and Grood, E. S. "Knee Ligament, Function and Failure. Clinical Application of Biomechanics, Biamechanical Test and Concepts." Presented at the American Orthopaedic Society for Sports Medicine, Las Vegas, Nevada, 1977.

27. Feagin, J. A., and Colonel, Curl W. "Isolated Tear of the Anterior Cruciate Ligament: 5 Year Follow Up Study." The American Journal of Sports Medicine 4 (1976): 95-100.

28. Chick, R. R., and Jackson, D. W. "Tears of the Anterior Cruciate Ligament in Young Athletes." Journal of Bone and Joint Surgery 60-A (1978): 970-73.

29. Feagin, J. A.; Abbott, H. G.; and Rokous, J. R. "The Isolated Tear of the Anterior Cruciate Ligament." Journal of Bone and Joint Surgery 54-A (1972): 1340-41.

30. Hughston, J. C. "Lnee Surgery: A Philosophy." Physical Therapy 60 (1980): 1611-14.

31. Malone, T.; Blackburn, T.; and Wallace, L. "Knee Rehabilitation," Physical Therapy 60 (1980): 1602-10.

32. Yamamoto, S. K.; Hartman, C.; and Feagin, J. "Functional Rehabilitation of the Knee: A Preliminary Study." The American Journal of Sports Medicine 6 (1975): 288-91.

33. Yocum, L.; Blackman, D.; Noble, H.; and Hoover, R. "The Deranged Knee: Restoration of Function." The American Journal of Sports Medicine 6 (1978): 51-53.

34. Jones, A. "Rehabilitation for Anterior Instability of the Knee: Preliminary Report." The Journal of Orthopaedic and Sports Physical Therapy 3 (1982): 121-28.

35. Briggs, B. "Rehabilitation Pertaining to Anterior Cruciate Tears." Interview, March 6, 1982.