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Outcome Study of Physical Therapy Rehabilitation of Patients with Patellar Femoral Dysfunction

Thomas D. Henke
University of North Dakota

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OUTCOME STUDY OF PHYSICAL THERAPY REHABILITATION
OF PATIENTS WITH PATELLAR FEMORAL DYSFUNCTION

by

Thomas Henke
Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2000
This Independent Study, submitted by Thomas Henke in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

Renee MacCoy
(Faculty Preceptor)

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(Graduate School Advisor)

Thomas Moth
(Chairperson, Physical Therapy)

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PERMISSION

Title  Outcome Study of Physical Therapy Rehabilitation of Patients with Patellar Femoral Dysfunction

Department  Physical Therapy

Degree  Master of Physical Therapy

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Signature  Thomas D. Hunger

Date  May 4th, 2000
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ABSTRACT

This study was conducted to assist St. Alexius Medical Center’s Institute of Sports Medicine in the analysis of physical therapy outcomes for patients who underwent patellofemoral surgical procedures including lateral retinacular release, vastus medialis oblique advancement, and tibial tubercle transfers. A review of data collected by the physical therapists at St. Alexius was performed and statistically analyzed to determine the efficacy of outcomes both clinically and functionally. This outcome analysis will assist current and future practice patterns by providing a basis for clinical effectiveness. The results of this study will be a useful resource for the facility as a guide to ensure quality improvement and as a tool for quantifying treatment to third party payers.

Overall, satisfactory outcomes, as determined by predetermined goals, were obtained by all patients for all areas of rehabilitation. On average, knee range of motion was functional and within protocol goals with no differences noted secondary to surgical procedure or patient’s age. Pain was kept to a minimum and was found to have no correlation with the age of the patient or return of strength. Joint effusion was also within the protocol goals and showed no correlation with achieved range of motion. Functional assessment demonstrated satisfactory results, overall, with transfers, ambulation, and activities of daily living.
CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

There have been dramatic changes within the United States health care system in recent years. Medical professionals have been forced to become more accountable for their actions as the health care system transitions from a fee-for-service toward the highly competitive, cost-conscious environment of managed care.¹ Those footing the bill for individuals want to see efficient, cost-effective results, allowing the patient to return to the highest level of function possible with the utmost satisfaction.² This has forged a new approach to health care which encompasses health, well-being, function, and disease; all are balanced by the cost of care provided.³ This transition is summed up in a statement by Relman² when he states that an era of "Cost Containment" has been replaced by an era of "Assessment and Accountability," a "revolution" in which the outcomes movement plays a key role.

Outcome studies allow clinicians the opportunity to evaluate the services provided, making sure they are appropriate, effective, and efficient while attaining a degree of functionality and maximal independence in activities of daily living (ADL).²⁴ In turn, providers are being furnished with well-substantiated guidelines for client management and third party payers are using the guidelines as a "yardstick," holding health care facilities accountable for appropriate, cost-
efficient care. Studies provide a benchmark for insurance carriers and managed care providers to assess quality and have led them to a greater understanding of the fact that high quality care is less expensive in the end than low or average care.

Historically, professionals documented for reimbursement. But in today's realm, professionals are being asked to document effectiveness. Outcomes documentation and outcomes research now focus on success of functional activities. The functional outcomes are measured by practicality and meaningfulness to the quality of life that the patient is able to maintain upon discharge, allowing for the greatest level of independence. Concepts of restricted range of motion are separated from the functional outcomes that one emphasizes in today's rehabilitation.

The outcomes movement has taken a patient-centered approach, not only allowing professionals to decide when patients are better, but including what the patient has to say about his or her results of care. Professionals are making sure that the needs of the patient are met, allowing them to live independently.

There are three driving forces behind the outcome movement. Epstein states that one is the need for cost containment. The escalating cost of health care has brought about the managed care and health care maintenance organizations (HMO) of today. Out of these has come the increased need for outcome studies. These studies are being used for reimbursement justification, treatment cost predictions, direction and development of practice guidelines, and as a tool for policy makers. Outcome studies have allowed an opportunity to provide
objective evidence as to treatment efficiency in producing expected outcomes. However, as Epstein\(^2\) stated, the purpose of such studies may be either an "index of the relative effectiveness of different interventions that allow the cutting of unnecessary cost" or as part of a monitoring system that does not so much improve quality of care but "detects it deterioration." Outcome studies need to be viewed as a valuable tool for the advancement of treatment in today's health care. Along with health care reform, outcome measures have reshaped our focus, emphasizing functional, patient level outcomes or activities of daily living rather than clinical outcomes, such as range of motion measurement. This in turn allows for a more independent way of life for patients.

A second factor in the development of the outcomes movement is the competitive nature of health care facilities.\(^2\) Facilities are attempting to provide third-party payers and clients with information as to their service, rehabilitation programs, and cost efficiency. Each one strives to meet client expectations while continuing to provide the highest level of cost-efficient care.

The third factor in outcomes assessment was a geographical difference in the use of a variety of medical procedures.\(^2\) This variety may result in unnecessary and excessive expense in the regional areas of high procedural use, resulting in inadequate reimbursement for the rehabilitation required and, in turn, a decreased level of patient satisfaction and independence after treatment. A study by Wennberg\(^2\) found that at times even "nonmedical" factors, such as geographical variations seen in medical practice, were greater influences on outcomes than were "hard" factors directly affecting treatment. This indicates
that there may be multiple factors outside the medical realm which may have a profound effect on the medical treatment that people receive.

Some great accomplishments have come from the implementation and use of outcome studies. Two of the most prominent advancements include improved clinical response through standardized protocol development and better health care for all patients. Standardized protocols are a set of treatment guidelines to be used by health care professionals for a given diagnosis. Some fear that standardization may interfere with autonomy, but ultimately it is intended to provide security by publishing guidelines for patient care and decreasing liability while attempting to guide cost-efficient care.

As with all good things come many challenges. The greatest challenge faced by those in outcome studies is the retrieval of information. While attempting to increase the knowledge base and understanding of successful rehabilitation, outcome studies are regularly stretched out over a great deal of time, often two years or more. This makes it increasingly difficult to continue the collection of quality information due to the inability to retain patient attendance for evaluation when it is not mandatory. Therefore, successful completion of a study is a valuable accomplishment due to the information provided and its importance to future reference for all those involved in rehabilitation.

Outcomes and the Patellofemoral Joint

As part of the many changes that have occurred with health care reform, physical therapists have become more accountable for their actions involving all forms of rehabilitation. Outcomes studies allow physical therapists the
opportunity to record information for multiple diagnoses and, upon analysis, display the progressive nature and expected results of the rehabilitation programs of today. Due to the complex nature of both conservative and surgical treatments for patellofemoral dysfunction, attempts are being made to determine if there are factors that may predetermine patients' outcomes from rehabilitation. This patellofemoral outcome study will attempt to analyze data from St. Alexius Medical Center to establish an understanding of demographics of the treatment groups and additional factors that affect patients' patellofemoral rehabilitation.

Patellofemoral Joint Anatomy

Patellofemoral joint dysfunction is a multifactorial problem resulting in numerous rehabilitation referrals each year. However, before discussing rehabilitation and surgical procedures used in treatment, there must be an understanding of the functions of the patella. First, quadriceps force for knee extension increases by 25% to 30% due to the increased moment arm of the quadriceps. Second, coefficients of friction are reduced due to a cartilage on cartilage articulation, which facilitates increased efficiency of quadriceps function. Third, it transmits forces of the four heads of the quadriceps muscle by centralizing them to the patellar head. Fourth, high compressive load tolerance of the knee is increased, protecting the quadriceps and patella from friction. Fifth, the patella serves to protect the joint and articular cartilage by acting as a bony shield for the anterior femur and tibia. Finally, the patella serves a cosmetic feature, producing a more appealing appearance.
Three primary forces largely control the patella and tracking of its movements. First is the oblique head of the vastus medialis muscle. It inserts on the medial aspect of the patella, usually at greater than a 55° angle. The purpose of the vastus medialis oblique (VMO) is to maintain the patella from lateral translation, not to assist with the attainment of terminal knee extension from 30° to 0° of extension. The VMO ultimately acts as the primary dynamic medial stabilizing force to maintain patellar alignment.

The lateral patellofemoral ligament, capsule, and iliotibial tract provide stabilizing forces for the lateral patella, guiding the knee through range of motion. Mechanically, patellar tracking may be altered by a shortening of the iliotibial band due to its posterior pull on the patella upon knee flexion or an increase in the height of proximal insertion, resulting in lateral patellar translation and facet compression. Both of these situations increase the load of the patella on the lateral facet with lateral translation.

Distally, the patella is attached to the tibia by the patellar ligament. The ligament supplies the distal anchor for the patella. The patella and ligament structure provide a load bearing surface to prevent anterior translation of the femur on the tibia.

Static osseous components are key factors as well within the knee. They assist with proper patellar tracking. Osseous components include the femoral sulcus depth, wall height of the lateral femoral condyle, and patellar shapes. It is when imbalances or disturbances such as injury occur to any one or all of these structures that malalignment of the patella occurs. Often, this results in
pain and difficulty with daily activities. Health care professionals are then called upon for rehabilitation of these individuals, returning them to their previous lifestyle.

An additional factor that needs to be discussed when considering biomechanics and injury of the knee complex is the alignment of the Q angle. The Q angle is defined as a line drawn from the anterior superior iliac spine to mid patella and mid patella to tibial tubercle. Normal angles for males range from $8^\circ$ to $14^\circ$ and females' angles range from $11^\circ$ to $20^\circ$. However, there are no clearly defined boundaries concerning the Q angle, making it difficult for professionals to use such a mark to predict complications due to the angle.

Extremes of the Q angle result in an abnormal lateral force on the patella. Quadriceps contraction forces attempt to straighten this angle, in turn encouraging lateral patellar tracking which is highly specific for chondromalacia development. This development may lead to complaints of anterior knee pain and further patellofemoral involvement. The Q angle is not, however, a reliable indicator of patellar malalignment. The angle of patellar approach to the trochlea in early flexion is a greater predictor of pain presence.

Anterior knee pain is a noted problem with people in today's society. Diagnoses of anterior knee pain consist of patellofemoral pain syndrome, patellofemoral chondrosis, chondromalacia, extensor mechanism deficiency, patellar subluxation, dislocation, and lateral patellar compression syndrome to name a few. Patellar dislocation or subluxation, patellofemoral arthritis, plica syndrome, patellar tendonitis, bursitis, and overuse syndrome are only some of
the causes of patellofemoral pain seen today. Individuals displaying anterior knee pain most often complain of a variety of symptoms. Pain is typically of an insidious onset, bilateral, retropatellar, and medial to the joint or in the popliteal fossa. Dull, aching pain has been characteristically described, but may become sharp when felt upon activity. The list of symptoms may also include crepitus, pseudolocking of the knee with subluxation, difficulty ascending and descending stairs, clicking or snapping posterior to and around the patella, and anterior knee pain after prolonged sitting.

Many professionals agree that conservative treatment of patellofemoral dysfunction is the best choice. One study indicated a 70-90% success rate with conservative therapy for patellofemoral patients and another report found an 80% success rate. The University of Connecticut Medical Sports Injury/Knee Clinics found over a two-year period that 93% of all patellofemoral patients were treated successfully without surgery. However, success is very dependent upon convincing patients of the therapy's worth and achieving daily compliance with exercise programs. Through the use of quadriceps strengthening and stretching and hamstring stretching, along with hip abduction and adduction strengthening, patients can reach their goals. Goals include control of pain, rehabilitation of affected musculature, possible activity modification, and gradual return to function and activities.

A diagnosed pathology, inability to perform normal daily activities, or failure of conservative treatments results in the need for surgery in an attempt to alleviate the patient's difficulty. A thorough physical examination is required to determine
the exact cause of pathologic abnormalities, allowing the appropriate selection of a surgical procedure or combination of procedures to best meet each patient's needs. Documentation of anatomical alignment and tracking of the extensor mechanism, along with reproduction of the patient's primary symptoms, are goals of the all-important clinical examination. Three questions must be answered. Is the anterior knee pain purely a cartilage problem? Are there any underlying ailments? Is the problem in the peripatellar soft tissue? The evaluation also needs to include a variety of other measurements such as degree of anteversion, knee valgus, tibial torsion, foot pronation, and leg length discrepancy that may induce malalignment at the knee. Iliotibial band, hamstring, and quadriceps flexibility also need to be assessed for possible involvement in knee difficulties. After analyzing all of this information, one must decide if surgical intervention would be the intervention of choice for the patient. The success of any operation is dependent upon avoiding reinjury along with patient factors of history of prior surgeries, patient motivation, and compliance.

There are three surgical procedures that are used most frequently. They include lateral retinacular release, vastus medialis oblique advancement, and tibial tubercle transfer.

Surgical Procedures

The procedures discussed for treatment of patellofemoral dysfunctions consist of lateral retinacular release, proximal realignment (vastus medialis oblique advancement), and distal realignment procedures (tibial tubercle transfer).
Lateral Retinacular Release

Indications for an lateral retinacular release (LRR) include painfully tight retinaculum, minimal patellar arthrosis with patellar tilt, subluxation with significant Q angle changes, recurrent painful subluxation or dislocation due to malalignment, and minimal patellar arthrosis.\(^7\) LRR is performed by open incision or arthroscope in an attempt to allow the patella to return medially. Surgery involves incision of the capsule to create a division of the lateral retinaculum and release of distal vastus lateralis muscle fibers. Results of the lateral retinacular release may consist of denervation of the painful retinaculum and a mild alignment correction within the trochlear groove.\(^8\) Complications or difficulties with lateral retinacular release may include an excessively superior incision causing medial patellar subluxation or dislocation, post-surgical arthrofibrosis, reflex sympathetic dystrophy, quadriceps rupture, or postoperative hemarthrosis.\(^13\) Primary emphasis is placed upon controlling the hemarthrosis to limit the muscular inhibition and joint scarring. Small\(^10\) noted a complication rate of 7.2% for arthroscopic lateral retinacular release, the highest of all arthroscopic procedures. LRR has been found to improve tilt of the patella, but its effects on subluxation are still questioned.\(^15\) Instability is thought to require proximal soft tissue realignment or tibial tubercle transfer. To improve both tilt and subluxation, one may need to perform both the lateral retinacular release and an anterior-medial tibial tubercle transfer (TTT). A study on cadaver knees described by Reider et al\(^10\) found no effect of LRR on tracking when the lateral retinaculum is normal. LRR should be reserved for those patients with
abnormally tight lateral structures.\textsuperscript{10} Reports indicate that patients with chronic knee pain exhibited an average 30-point improvement (62-92) in functional scores after lateral retinacular release. Complete rehabilitation of the lateral retinacular release may require up to one year.\textsuperscript{8}

**Proximal Realignment**

Proximal realignment procedures attempt to centralize the location of the patella through reefing or tightening of the medial knee capsule.\textsuperscript{9} In turn, the resting length tension of the vastus medialis oblique increases, centralizing the patella and achieving the goals of this procedure. Of some concern with the procedure for vastus medialis is a limiting factor that may include muscle inhibition due to the sutures passed through the medial capsule. One also needs to be aware of the possibility of reflex sympathetic dystrophy due to entrapment of the saphenous nerve. Reflex sympathetic dystrophy needs to be treated within 2 to 3 weeks of onset to attain optimal rehabilitation. Rehabilitation is often times already guarded to avoid possibilities of suture rupture in proximal realignment patients. A lateral retinacular release is often performed in conjunction with proximal realignment.

**Distal Realignment**

Transfer of the patellar tendon and tibial tubercle medially is used on skeletally mature patients with recurrent lateral patellar subluxation and dislocation and lateral patellar tilt or increased Q angles with the goal of correcting improper patellar tracking.\textsuperscript{9} Surgically, the tibial tubercle is elevated, decreasing the patellar shear force. Reattachment is founded with cortical bone screws which
allow for early movement from 0° to 90°, but weight bearing is limited in early rehabilitation. Complications for distal realignment include inferior shift in patellar position, decreased active extensor range of motion control, fat pat fibrosis, and interference with incision closure secondary to localize hematoma development following osteotomy.9

Twenty-five percent shear force reduction of the patellofemoral joint is found with just a 1.5 cm anterior translation of the tibial tubercle.9 Others have found that a combination of an 8.8 mm anterior and 8.4 mm medial transposition decreases force in the lateral facet by 30% and 14.8 mm anterior and 8.4 mm medial transposition decreased force by 65%; measurement of forces are taken with the knee at 10° of knee flexion. Independently, anterior-medial tibial tubercle transfer improves subluxation, but when combined with lateral retinacular release tilt is improved along with the functional scores of the patient.15 Results also include an increased lever arm for extensor function, allowing for greater quadriceps efficiency while decreasing articular reaction forces acting upon the patellofemoral joint.11 Contact pressures are shifted more medially and slightly proximal on the articular patellar surfaces with the procedure, attempting to equalize pressure of facets. At 10° knee flexion, a 30% reduction in lateral facet pressure was measured and at 20°, facet pressure was equalized.14 With the transfer, good to excellent subjective results have been found in 85% of patients at 19 months follow-up and 93% at 35 months follow-up in one study with the use of the transfer. These patients displayed and average 21.6° pre-operative and 12° post-operative Q angle.
Rehabilitation

Post-surgical goals of patellofemoral rehabilitation are to decrease pain and re-establish function through restoring ROM, muscle function, coordination, and dynamic functions of the lower extremity.\textsuperscript{8,9} Superior, medial, and lateral patellar mobilizations are key to patellar movement and need to be carried out 6 to 8 times per day, preventing scar tissue development.\textsuperscript{9} Superior patellar tendon mobility may be restricted without proper mobilization and result in extensor lag. The patellar tendon will eventually shorten and, once again, the shear force of the joint will have increased. Proper instruction and positioning is needed for range of motion and mobilization exercises to be carried out in short burst of 5 to 10 minutes. Isometrics and straight leg raises are to begin as soon as possible, limited only by patient pain and potential joint hemarthrosis. The primary exercises are to be isometrics carried out at 0°, 30°, 50°, 70°, and 90° of flexion. Patients are to maintain the least amount of pain with voluntary muscle contractions at the angles noted. If weight bearing is permitted, early exercises may include closed chain hip abduction and adduction. Partial weight bearing is permitted with all procedures to assist with re-establishment of muscular function, increased articular surface nourishment, improved neuromuscular function, and increased confidence in closed chain activities. Patients are to return to full activity based on reports of symptoms and pain patterns, objective assessment of patellar mobility, and quadriceps control. Return to functional activities is based on an isokinetic muscle control evaluation demonstrating a 30% or less quadriceps deficiency when compared to the contralateral lower
extremity. Functional hop tests are also used to compare the lower extremities. Greater than a 15% deficit for the involved extremity results in continued exercise programs as well as recreational and occupational limitations.

This study identifies and analyzes patellofemoral outcomes from patients seen at St. Alexius Medical Center, comparing these rehabilitation outcomes with those of other researchers. Attempts are made to ascertain which factors may or may not have adverse affects on the rehabilitation of the patients.
CHAPTER II

METHODS

Study participation included 17 subjects for data analysis following patellofemoral surgery. Subjects volunteered for longitudinal outcome studies during rehabilitation at St. Alexius Medical Center in Bismarck, North Dakota. Participation in this study was dependent upon patients giving signed consent allowing rehabilitation and collection of data by the clinical physical therapists employed at St. Alexius Institute of Sports Medicine. Physical therapists performing the rehabilitation and data collection used a standard form to collect data from December 1995 to January 1999. Authorization for this study was secured through the Institutional Review Board of the University of North Dakota and the St. Alexius Medical Center.

Data Collection

Data were collected from 17 subjects, 19 knees, following surgery at the predetermined intervals of two weeks, three weeks, seven weeks, ten weeks, six months, one year, and two years. Data collected beyond ten weeks were done voluntarily without cost to the patient and performed solely for the purpose of gathering information. Due to the fact that information collected beyond ten weeks of the patient's rehabilitation was done for clinical use, participation varied resulting in incomplete information for some patients. Allowances were made for
patients with incomplete files; data collected at appropriate time periods was still utilized for inclusion into this study.

Instrumentation and Procedure

Data were collected with various means of both subjective and objective tests and measures. Measurements include knee range of motion, patient's pain rating, quadriceps strength, joint effusion, self reported function, patellar mobility, isokinetic testing, as well as other patient demographics.

Knee Range of Motion

Range of motion measurements of the involved knee were taken during each visit using a standard, double-armed goniometer with full 360° range. Measurement techniques followed standard clinical practice outlined in *Measurements of Joint Motion: A Guide to Goniometry* by Norkin and White.\(^1^6\) Knee range of motion was measured passively with the patient in a supine position on a firm surface. Active range of motion was also measured using the same principles, however, in an antigravity, seated position.

Functional Range of Motion

Functional range of motion for knee flexion was defined by the researchers as 117° or greater as stated in *Orthopedic Assessment* by Magee.\(^1^7\) Measurements of 116° or less were considered non-functional.

Pain Rating

Patient subjective pain rating was recorded with each visit. Patients were asked to rate their pain on a scale of 0 to ten with 0 being no pain and 10 being their worst pain as found in Magee.\(^1^7\)
Quadriceps Strength Testing

Manual muscle testing of the quadriceps muscle was performed beginning with the seventh week visit. Testing was done using the standard methods outlined by Magee. Measurements were graded by the physical therapist on a scale of 0 (no contraction) to 5 (maximum resistance against gravity through complete range of motion).

Joint Effusion

Joint effusion was measured at the patient's mid patella, with the knee in full extension, using a standard cloth tape. Palpating for superior and inferior borders of the patella and measuring at the midpoint determined measurement landmarks. Knee girth was recorded in centimeters at two weeks postoperatively. Effusion data were analyzed as an edema difference between the involved and uninvolved limb. This difference was calculated by subtracting the measurement of the uninvolved limb from the measurement of the involved limb. An edema ratio was also developed by dividing the involved knee measurement by the uninvolved knee measurement.

Functional Tests

Self reported functional data were recorded by the physical therapist using a standardized, lower extremity, functional assessment form (Appendix A). This form uses a numerical scale from 1 (non-satisfactory level of function) to 5 (satisfactory level of function). Functional activities on the form include:

1) quality of ambulation on level ground, distance of ambulation, and stair
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climbing, 2) transfers of toilet, tub, chair, and car, and 3) daily activities of
dressing, work, and recreation.

Data were analyzed at the 52-week visit. A total score was calculated with a
maximum possible score of 50. A sum of the subject's scores was tallied and
used to calculate a total raw score, which was compared with the maximum of
50.

Patient Demographics

Other information included on the patient's outcome form included age,
gender, date of injury, date of surgery, type of surgery, doctor, occupation, and
dominant lower extremity. This information is used to draw comparisons
between patients of both similar and different demographics and surgical
procedures.

Age

Age was recorded as the original number in years. Subjects were then
divided into three equal groups, based on age ranges of 25 years, for statistical
analysis of functional knee flexion return. The first group was 0-25 years, the
second 26-50 years, and the last 51-75 years. This was an attempt to further
specify which age groups may or may not display a return to functional range of
motion at 10 weeks.

Bilateral Subjects

Various data analyses were performed excluding the bilateral surgery subjects
due to the fact that they lacked a control or uninvolved extremity for
comparison upon evaluation. Periods of exclusion within the results are noted when appropriate.

Data Collection/Analysis

Data were provided for the researcher through the use of an already established collection sheet as part of St. Alexius outcome study. A data collection sheet included a wide range of material, much of which is listed above and will be analyzed within this study. Data from patient charts were compiled into SPSS on one data file. Statistical procedures were used to describe values and analyze differences and relationships between and among the variables. For all statistical tests, an alpha level of 0.05 was utilized. Data reporting was accomplished using the form established by St. Alexius physical therapists (Appendix A). Chapter III includes the results supported by tables which contain the statistical and descriptive data.

Reporting of Results

The results of this independent study will be stored at St. Alexius Medical Center Institute of Sports Medicine for further reference.
CHAPTER III
RESULTS

All of the 17 subjects selected for study participation were used for data analysis. Of the 17 subjects, two were bilateral patients giving a total of 19 patellofemoral joints assessed. Selected measurement comparisons were deemed invalid secondary to the bilateral patients failing to have a non-involved limb for reference of pre-injury status. Instances of exclusion of such data will be noted as it is addressed in this section.

Due to possible bilateral involvement, as stated above, the number of subjects varied for each data category analyzed. In addition, the number of subjects varied for each phase of measurement secondary to subject participation.

The patellofemoral surgical procedures were performed by one of four orthopedic surgeons employed by the St. Alexius Medical Center. Each surgeon included patients within this study. Data were grouped according to the type of patellofemoral surgery performed to draw comparisons between each. However, data will also be compared in a combined manner to draw conclusions about patellofemoral surgeries and rehabilitation regardless of surgery performed.

Post-surgically, all subjects were treated by St. Alexius physical therapists using the guidelines outlined in the rehabilitation protocol (Appendix B).

Of the 17 subjects, 3 (18%) were male and 14 (82%) were female. The
subjects ranged in age from 13 to 70 years with a mean age of 27 (±17.01) years. The sample age range was positively skewed secondary to 59% of the subjects being 19 years of age or younger. Of the three surgeries performed, 11 (58%) were a lateral retinacular release, 3 (16%) a VMO advancement, and 5 (26%) a tibial tubercle transfer. It should be noted that all tibial tubercle transfer procedures were performed with inclusion of a lateral retinacular release. 

Research Question #1 – Is there a significant difference in return of functional range of motion based upon surgical procedure at 10 weeks post surgery?

Lateral Retinacular Release (LRR)

Average knee range of motion measurements for lateral retinacular release subjects at 10 weeks post-surgery are reported in Table 1. Mean range of motion measurements, active and passive, were shown to be in functional range for both extension and flexion respectively. Passive extension noted an extensor lag upon evaluation of 0.78°. Analysis of Variance (ANOVA) determined no significant difference in ROM between rehabilitation time intervals (weeks 2, 3, 7, and 10) for passive extension [F (3,34) = 1.21, p > 0.05] or active extension [F (3,34) = 0.57, p > 0.05]. There is a significant difference between time intervals for passive and active flexion and the results are reported in Table 1. Overall, Scheffes' post-hoc testing displayed a significant improvement in
Table 1. Lateral Retinacular Release: ROM in Degrees and ROM Comparisons Between Time Intervals

Range of Motion at 10 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Extension</td>
<td>9</td>
<td>0.78</td>
<td>1.92</td>
</tr>
<tr>
<td>Active Extension</td>
<td>9</td>
<td>4.22</td>
<td>3.77</td>
</tr>
<tr>
<td>Passive Flexion</td>
<td>9</td>
<td>134.00</td>
<td>6.30</td>
</tr>
<tr>
<td>Active Flexion</td>
<td>9</td>
<td>127.13</td>
<td>8.22</td>
</tr>
</tbody>
</table>

ANOVA for ROM Comparisons Between Time Intervals

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>4800.9</td>
<td>3</td>
<td>1600.3</td>
<td>3.6</td>
<td>0.24</td>
</tr>
<tr>
<td>Within groups</td>
<td>14673.8</td>
<td>33</td>
<td>444.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19474.7</td>
<td>36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>2315.8</td>
<td>3</td>
<td>771.9</td>
<td>3.1</td>
<td>0.42</td>
</tr>
<tr>
<td>Within groups</td>
<td>6934.1</td>
<td>28</td>
<td>247.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9249.0</td>
<td>31</td>
<td></td>
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</tbody>
</table>

Scheffe Post Hoc Results for ROM at Weeks 2 and 10

<table>
<thead>
<tr>
<th></th>
<th>ROM</th>
<th>Mean Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>103.00</td>
<td>31.00*</td>
<td>0.036</td>
</tr>
<tr>
<td>Week 10</td>
<td>134.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>120.57</td>
<td>24.55*</td>
<td>0.046</td>
</tr>
<tr>
<td>Week 10</td>
<td>127.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Mean difference is significant at the 0.05 level.
ROM between weeks 2 and 10 post-surgery. The level of significance is reported within Table 1.

Vastus Medialis Oblique (VMO)

Average knee range of motion measurements for vastus medialis oblique subjects at 10 weeks post-surgery are reported in Table 2. Mean range of motion measurements, active and passive, were shown to be in functional range for both extension and flexion respectively. An extensor lag of 4.50° was noted upon evaluation at 10 weeks. There was a significant difference with ANOVA testing for range of motion measurements between weeks for passive and active flexion, as recorded in Table 2. However, this was not supported with post-hoc testing for the respective groups as recorded in Table 2. ANOVA testing found no significant difference between groups for passive extension [F (3,7) = 0.071, p > 0.05] or active extension [F (3,4) = 0.131, p > 0.05].

Tibial Tubercle Transfer (TTT)

Average knee range of motion measurements for tibial tubercle transfer subjects at 10 weeks post surgery are reported in Table 3. Mean range of motion measurements, active and passive, were shown to be in functional range for both extension and flexion respectively. Upon evaluation, a 2.0° extensor lag was noted with passive extension. A significant difference was noted for passive and active flexion between weeks 2 and 7 as well as between weeks 2 and 10 as determined by post-hoc analysis. Table 3 shows there was a significant difference between time periods for active and passive flexion. Table 3 shows
Table 2. Vastus Medialis Oblique: ROM in Degrees and ROM Comparisons Between Time Intervals

Range of Motion at 10 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Extension</td>
<td>2</td>
<td>-4.50</td>
<td>6.36</td>
</tr>
<tr>
<td>Active Extension</td>
<td>2</td>
<td>4.00</td>
<td>5.66</td>
</tr>
<tr>
<td>Passive Flexion</td>
<td>2</td>
<td>151.00</td>
<td>5.66</td>
</tr>
<tr>
<td>Active Flexion</td>
<td>2</td>
<td>144.50</td>
<td>7.78</td>
</tr>
</tbody>
</table>

ANOVA for ROM Comparisons Between Time Intervals

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>6545.8</td>
<td>3</td>
<td>2181.9</td>
<td>5.6</td>
<td>0.036</td>
</tr>
<tr>
<td>Within groups</td>
<td>2345.8</td>
<td>6</td>
<td>390.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8891.6</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>7850.9</td>
<td>3</td>
<td>2616.0</td>
<td>4.5</td>
<td>0.047</td>
</tr>
<tr>
<td>Within groups</td>
<td>4077.8</td>
<td>7</td>
<td>582.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11928.7</td>
<td>10</td>
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Scheffe Post Hoc Results for ROM at Weeks 2 and 10

<table>
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<tr>
<th></th>
<th>ROM</th>
<th>Mean Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>88.57</td>
<td>62.33</td>
<td>0.071</td>
</tr>
<tr>
<td>Week 10</td>
<td>151.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>76.67</td>
<td>67.83</td>
<td>0.095</td>
</tr>
<tr>
<td>Week 10</td>
<td>144.50</td>
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<td></td>
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</table>
Table 3. Tibial Tubercle Transfer: ROM in Degrees and ROM Comparisons Between Time Intervals

Range of Motion at 10 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Extension</td>
<td>5</td>
<td>-2.00</td>
<td>3.74</td>
</tr>
<tr>
<td>Active Extension</td>
<td>5</td>
<td>2.00</td>
<td>1.22</td>
</tr>
<tr>
<td>Passive Flexion</td>
<td>5</td>
<td>146.40</td>
<td>5.55</td>
</tr>
<tr>
<td>Active Flexion</td>
<td>5</td>
<td>138.40</td>
<td>6.43</td>
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</table>

ANOVA for ROM Comparisons Between Time Intervals

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
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<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>14452.0</td>
<td>3</td>
<td>4817.4</td>
<td>8.6</td>
<td>0.0001</td>
</tr>
<tr>
<td>Within groups</td>
<td>8441.0</td>
<td>15</td>
<td>562.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22894.0</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>11897.8</td>
<td>3</td>
<td>3965.9</td>
<td>5.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Within groups</td>
<td>9901.2</td>
<td>14</td>
<td>707.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>21798.9</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post Hoc Results for ROM at Weeks 2 and 7

<table>
<thead>
<tr>
<th></th>
<th>ROM</th>
<th>Mean Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>77.00</td>
<td>63.75*</td>
<td>0.01</td>
</tr>
<tr>
<td>Week 7</td>
<td>140.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>73.00</td>
<td>65.25*</td>
<td>0.03</td>
</tr>
<tr>
<td>Week 7</td>
<td>138.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Tibial Tubercle Transfer: ROM in Degrees and ROM Comparisons Between Time Intervals (Cont.)

Post Hoc Results for ROM at Weeks 2 and 10

<table>
<thead>
<tr>
<th></th>
<th>ROM</th>
<th>Mean Difference</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>77.00</td>
<td>69.40*</td>
<td>0.01</td>
</tr>
<tr>
<td>Week 10</td>
<td>146.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2</td>
<td>73.00</td>
<td>65.40*</td>
<td>0.02</td>
</tr>
<tr>
<td>Week 10</td>
<td>138.40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Mean difference is significant at the 0.05 level.

the differences at weeks 2 and 7 along with 2 and 10 respectively. ANOVA summary determined there was no significant difference between time periods for passive extension \[F (3,15) = 2.04, p > 0.05\] or active extension \[F (3,13) = 2.16, p > 0.05\].

The greatest ROM at 10 weeks was seen with patients who underwent VMO advancement with measurements of 151.0° for passive flexion and 144.5° for active flexion. Descriptive analysis of all three surgical procedure groups demonstrated functional knee flexion at the ten-week visit.

**Research Question #2 – Is there a correlation between pain and return of strength based on utilization of manual muscle testing (MMT)?**

Overall, pain measurements at week 7 involved 17 subjects with a mean pain rating of 0.47. MMT during this time involved 8 subjects with a mean of 4.2 for quadriceps strength. Upon evaluation, there was no significant correlation between pain rating and return of strength with use of patient’s subjective pain.
description and clinical evaluation of manual muscle testing as shown in Table 4.

The analysis of pain and strength displayed no correlation with the use of Spearman's rho ($r_s = 0.734, p > 0.05$).

Table 4. Correlation Between Pain Rating and Manual Muscle Test Strength at Week 7

<table>
<thead>
<tr>
<th></th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Pearson Correlation Coefficient</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>17</td>
<td>0.47</td>
<td>1.07</td>
<td>-0.144</td>
<td>0.734</td>
</tr>
<tr>
<td>Quadriceps Strength</td>
<td>8</td>
<td>4.13</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Question #3 – Is there a correlation between subjective pain reports and the subject’s age?

Upon data analysis, there was no significant correlation between pain and the subject’s age reported in Table 5. Data were utilized from 18 subjects with pain reports taken at week 2. The analysis of pain and age displayed no correlation with the use of Spearman’s rho ($r_s = 0.86, p > 0.05$).

Table 5. Correlation Between Pain Rating and Age Group

<table>
<thead>
<tr>
<th></th>
<th>Number of Subjects</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Pearson Correlation Coefficient</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>18</td>
<td>2.0</td>
<td>1.75</td>
<td>-0.18</td>
<td>0.469</td>
</tr>
<tr>
<td>Age</td>
<td>19</td>
<td>26.5</td>
<td>16.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Question #4 – Is there a significant correlation between functional range of motion and joint effusion at two weeks?
Upon data analysis, joint effusion did not have a significant correlation with active or passive functional ROM at two weeks post-surgery as shown with the use of Spearman's rho for active \( (r_s = 0.053, p > 0.05) \) and for passive \( (r_s = 0.234, p > 0.05) \) ROM. Data for ROM, active or passive, are recorded in Table 6. The median edema difference, when the affected limb was compared to the unaffected limb, was 1.65 cm showing that 50% of subjects were below this level. Minimum edema difference found was 0.30 cm with a maximum of 3.00 cm.

Table 6. Correlation Between Edema and Passive Flexion and Edema and Active Flexion

<table>
<thead>
<tr>
<th></th>
<th>Number of Subjects</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>( r_s )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edema Ratio</td>
<td>14</td>
<td>1.01</td>
<td>1.07</td>
<td>1.05</td>
<td>-.02</td>
<td>-226</td>
<td>.436</td>
</tr>
<tr>
<td>Passive Flexion</td>
<td>14</td>
<td>37.00</td>
<td>130.00</td>
<td>95.29</td>
<td>32.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edema Ratio</td>
<td>14</td>
<td>1.01</td>
<td>1.07</td>
<td>1.05</td>
<td>-.02</td>
<td>-132</td>
<td>.698</td>
</tr>
<tr>
<td>Active Flexion</td>
<td>11</td>
<td>37.00</td>
<td>121.00</td>
<td>92.00</td>
<td>31.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research Question #5 – Is there a correlation between age and return to functional knee flexion?

Fifteen subjects at 10 weeks were analyzed relative to age and functional range of motion for passive and active flexion as shown in Table 7. The sample of subjects was not large enough to establish a correlation coefficient.
Table 7. Number of Patients Achieving Functional Flexion at 10 Weeks by Age Group

<table>
<thead>
<tr>
<th>Age Groups in Years</th>
<th>0-25</th>
<th>26-50</th>
<th>51-75</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-functional ROM</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Functional ROM</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Active Flexion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-functional ROM</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Functional ROM</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>14</td>
</tr>
</tbody>
</table>

Therefore, descriptive analysis was utilized and found no trend between age and return to functional range of motion. Of 15 subjects recorded at 10 weeks, all achieved the criterion for functional passive knee flexion. Data for functional active flexion indicated that 14 of 15 achieved the criterion. The subject who did not reach the functional measure was in the third age group (51-75 years), displaying a measurement of $115^\circ$ at 10 weeks.

Research Question #6 – What were the results of the functional assessment performed throughout rehabilitation regardless of the surgical procedure performed?

Descriptive statistics of functional assessment are reported in Table 8 with mean scores for each functional activity. Total scores of 50 points were possible for the functional assessment, including 15 points for ambulation, 20 for transfers, and 15 for daily activities. Nine different subjects performed a total of 14 functional assessments throughout the time period of 3 months to 24 months. Score variation, from highest to lowest, was 5.0 points for ambulation, 3.0 points
Table 8. Functional Assessment: Component Means and Total Score Means

<table>
<thead>
<tr>
<th>Visit</th>
<th>N</th>
<th>Ambulation Score Mean</th>
<th>Transfer Score Mean</th>
<th>Daily Activities Score Mean</th>
<th>Total Score Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 months</td>
<td>1</td>
<td>10</td>
<td>19</td>
<td>12</td>
<td>41</td>
</tr>
<tr>
<td>6 months</td>
<td>3</td>
<td>14.1</td>
<td>18.0</td>
<td>14.3</td>
<td>46.4</td>
</tr>
<tr>
<td>12 months</td>
<td>8</td>
<td>13.5</td>
<td>18.6</td>
<td>13.9</td>
<td>46</td>
</tr>
<tr>
<td>24 months</td>
<td>2</td>
<td>15</td>
<td>19.5</td>
<td>15</td>
<td>49.5</td>
</tr>
</tbody>
</table>

for daily activities, and 1.5 points for transfers. The greatest improvements were seen with ambulation and daily activity means, while the least improvement was seen with transfers. However, it should be noted that for each visit throughout rehabilitation, transfer means were maintained above satisfactory levels. Mean totals displayed satisfactory functional achievement, 40.0 or greater, for each visit.
CHAPTER IV
DISCUSSION

The diagnosis, evaluation, and treatment of the patellofemoral joint remain a challenge for the physical therapist today. This study attempts to analyze the results of various aspects for the post-surgical patellofemoral rehabilitation program and factors that may affect its outcomes. Variables evaluated include range of motion, pain, strength, subject age, joint effusion, and function.

Range of Motion

A big part of the post-operative rehabilitation is the range of motion. With the lateral retinacular release, 90° of flexion is to be attained within one week. There were no data collected for this study at one week of rehabilitation. St. Alexius lateral retinacular release patients were able to show a functional range of motion as described by Magee at 10 weeks for both active and passive flexion. This allows for activities such as squatting to tie one’s shoes or pull on socks.

Range of motion for both active and passive flexion of lateral retinacular release patients changed significantly over time. The most significant improvement was found between weeks 2 and 10. This is due to the fact that
this eight-week time span is the greatest time frame investigated by this study, allowing for the greatest amount of rehabilitation achievement to take place.

Range of motion goals for St. Alexius patients for lateral retinacular release include full knee flexibility (Appendix B). Patients were able to demonstrate active extension of 4.22° and active flexion of 127.13°. This demonstrates an overall lack of active extension at the 10-week period. However, patients were able to demonstrate passive extension to 0.78° and passive flexion to 134.00°, demonstrating the ability to attain full range of motion. This indicates that it may be the strength component of rehabilitation that needs to advance to allow for increased range of motion.

Patients of the vastus medialis oblique (VMO) procedure demonstrate a greater quantitative degree of functional flexion at 10 weeks when compared to patients with lateral retinacular release or tibial tubercle transfer. Passive flexion for patients with the VMO procedure is 151° and active flexion is 144.5°. This is well in excess of the 117° reported by Magee\textsuperscript{17} as necessary for functional activity. The reported VMO results may, however, be somewhat misleading due to the limited number of subjects (n=3) used for the data reporting. It is important to increase the number of subjects studied within the VMO procedure before attempting to apply the results to a greater population.

With the VMO patients, the range of motion difference was found to be significant in both the passive and active flexion between weeks 2 and 10. This is thought by this researcher to be due to the fact that this is the largest time frame investigated by the study, allowing for the greatest rehabilitation and
therapy advancement. This eight weeks allows for the greatest improvement in the range of motion.

Discharge goals for range of motion included in the VMO protocol include attainment of normal range of motion (Appendix B). It would appear as if the VMO procedure meets this goal for flexion, both passive and active, at 10 weeks. The 4° of active extension and 4.50° hyperextension passively indicate that the patient demonstrates the ability to achieve normal range of motion actively with further rehabilitation. It would appear as if the strength increase is once again needed to attain the normal range of motion due to the hyperextension that is observed passively. Once again, these data are difficult to apply to those of a larger population due to the limited number of subjects (n=3).

Tibial tubercle transfer (TTT) patients demonstrated an average of 146.4° of passive flexion and 138.4° of active flexion, indicating achievement of the functional range of motion at 10 weeks post-operative rehabilitation. Significant differences in range of motion were found between weeks 2 and 7 as well as 2 and 10 for passive and active flexion of TTT patients. The significance between weeks 2 and 7 is due to the fact that TTT demonstrated the lowest mean when compared to the LRR and VMO at 2 weeks post-operative rehabilitation. However, TTT shows a 63.75° increase in the range of motion over the five weeks, the greatest improvement of the three procedures post-operatively. Patients of the TTT show the greatest increase in range of motion between weeks 2 and 10 when compare to LRR and VMO post-operatively. This is thought by the researcher to be due to the invasiveness of the procedure
requiring the movement of a bony segment of the tibial tubercle. This is why the patient shows the greatest limitation initially in rehabilitation, but is able to demonstrate such great return.

Protocol goals of the TTT procedure that were achieved include the full active range of motion (Appendix B). Overall patient profile demonstrates 2.0° of active extension and 2.0° of hyperextension passively at 10 weeks. Ten weeks of flexion finds active at 138.4° and passive at 146.4° range of motion, a level well above the functional criteria.

Age

As one ages, it is felt by many that the body and general conditioning tends to decline. It is generally thought that one is unable to heal as quickly or rebound from things as easily as those who are younger. As a possible predictor of poor outcomes for patellofemoral patients, advancing age has been mentioned, but support for this is not found in some studies. The current study was unable to demonstrate a correlation between subject’s age and pain level at two weeks of rehabilitation. Analysis was as well unable to demonstrate any correlation between age and return of functional range of motion at 10 weeks. The lone individual unable to achieve functional range of motion at 10 weeks was found in the oldest age group, which may suggest advancing age as a factor affecting rehabilitation. The subject was, however, within 2° of meeting criteria for functional range of motion. It may be that one could account for this through the error that may be found in goniometrical measurement.
Researchers Simpson and Barret Jr.\textsuperscript{19} found that with a LRR, advancing age was one of the factors that contributed to the poor results. They did note that you must differentiate chondromalacia and osteoarthritis when considering the affects of aging on outcomes. This takes into account the patellofemoral pain from biomechanical or traumatic occurrences versus those experienced due to aging.\textsuperscript{19} Busch and DeHaven\textsuperscript{18} reported that age does not affect the results of a LRR. Naranja et al\textsuperscript{20} found upon Elmslie-Tillat-Maquet procedure evaluation at an average of 74.2 months follow-up that a significant difference ($p < 0.05$) existed between the mean age of patients who were described as receiving excellent and good results as compared to those of fair to poor outcomes. Those who reported excellent and good results averaged 24.6 and 26.2 years, respectively. Those with fair and poor results averaged 30.1 and 31.5 years of age, respectively. This indicates that among the risk factors identified by the authors, age of 31.5 years is to be included.

As it would appear, mixed reviews are given as to the effects of age on patient's post-operative outcomes. There is little research explaining the specific effects of age on patellofemoral patients. Further, more detailed research with a large number of subjects is needed if any significant effects for age on rehabilitation or post-operative patellofemoral patients are to be described.

**Strength, Pain, and Effusion**

These three factors were difficult to separate into individual factors when researching so they will be observed and their effects on one another. Pain, effusion, and decreased strength are obstacles challenging therapists each day.
They affect patients both physically and mentally, increasing the obstacles that are to be overcome in rehabilitation. This study found no significant correlation between pain and the return of strength at week 7. Research has, however, found that pain may directly affect the contractility of the quadriceps muscle.\textsuperscript{21} The effects are negative, causing a decrease in the strength produced.

This study was also unable to find a significant correlation between return of functional range of motion and joint effusion at 2 weeks post-surgery. Research has shown that effusion may increase the irritability of the knee, directly and negatively affecting the quadriceps femoris contractility after surgery.\textsuperscript{21,23} The VMO has been shown to be inhibited by incorporation of only 20 to 30 ml of saline into the knee joint, while the rectus femoris and vastus lateralis require between 50 to 60 ml.\textsuperscript{22} It is the understanding of this researcher that the muscle inhibition experienced through the effusion may have an effect on the range of motion that one is able to attain. The ability of effusion to inhibit function demonstrates a need for careful evaluation and management of knee injured patients to limit the expression of negative effects. Attempts to enhance rehabilitation are achieved through minimization of effusion post-operatively with the use of cryotherapy and intermittent cold compression with elevation, leading to a quicker return of quadriceps function.\textsuperscript{21,23} Overall, recovery may be enhanced if effusion is minimized, allowing for earlier initiation of quadriceps strengthening and increased range of motion.\textsuperscript{21}

Merchant and Mercer\textsuperscript{10,19} reported that patients with LRR who were unable to maintain good quadriceps strength attained poorer outcomes. Micheli and
Stanitski\textsuperscript{19} found a directly proportional outcome between time required to increase quadriceps and hamstring strength and flexibility through vigorous therapy and the results that were achieved in rehabilitation.

Functional Assessment Overview

This functional assessment for patellofemoral patients was developed by St. Alexius Medical Center in an attempt to gain an understanding of patient's level of function along with clinical evaluation results (Appendix A). Assessment of patient's ambulation, transfers, and daily activities were included to assess the patient's functional achievement. An 80\% success rate was needed for individual activities as well as overall mean assessment for patients to attain a satisfactory score. This study found that patients at 3, 6, 12, and 24 months were all able to demonstrate a total mean satisfactory score. The greatest total mean score increase was seen between three and six months, a 5.4 point increase. Scores for each respective area of evaluation displayed an increase when examined between 3 and 24 months. Ambulation improved 5 points, transfers improved 0.5 points, and daily activities rose 3 points. Mean transfer score remained relatively stable throughout the evaluation process demonstrating that a satisfactory level of patient achievement for transfers occurred relatively soon post-operatively. Ambulation and daily activities increased when comparing 3 months to 6 months, but found a decrease when comparing 6 months to 12 months. This may be attributed to the fact that there was a larger patient pool from which to draw information at the 12-month interval, resulting in a more accurate, descriptive measure of the patients' outcomes in
this respective period. The three-month period had a limited number of subjects making it difficult to infer the results to a large population.

Fulkerson et al.\textsuperscript{13} with a scale of 1 for excellent or normal and 4 for poor results post-operatively, found a functional improvement of 1.6 points from 3.6 to 2.0 in activities including alterations in running, cutting, or rising from a chair. Another report, with the same reporting scale as that above, found a functional improvement from 3.4 pre-operatively to 1.7 post-operatively in patellofemoral patients.\textsuperscript{24}

Limitations

Of the limitations within this study and its completion, the greatest may be the fact that there are a wide variety of procedures that can be performed for patellofemoral dysfunction. Within the three surgical procedures studied here, there are multiple surgical procedures that are carried out for the treatment of patellofemoral dysfunction. This makes it difficult to generate a patient population involving similar procedures when attempting to evaluate outcomes. The use of multiple treatment is also a factor to be considered. One may undergo a lateral retinacular release with tibial tubercle transfer or may incorporate all three procedures to attain the greatest benefit for the patient. This makes it difficult to ascertain which treatment or combination of them may be the most effective. In the end, the procedure or combination of them needs to be employed that will result in the most successful outcome for the patient after rehabilitation. It is ultimately a successful outcome, in both the eyes of the
patient as well as the clinician that one hopes to achieve no matter what the procedure may be.

The 17 subjects available for evaluation are a limitation as well. Some question may arise as to whether or not these data are applicable to a larger population with such a small sample size. This study will need to be continued in order to make an effort to evaluate a larger sample, attempting to apply those results to describe post-operative patellofemoral rehabilitation patients. The small sample size is a factor that is often times difficult to overcome because participation in the study is voluntary. Patient completion of the two-year study is often difficult to accomplish. Even though a number of the long-term evaluations were of no charge to the patients, it is difficult to keep in contact and encourage patients to return for continuation of the study. Lack of completion of the study also makes for incomplete date analysis. This makes it difficult to discern any trends that may have developed.
APPENDIX A
LONGITUDINAL OUTCOME STUDY
SURGICAL/PATELLOFEMORAL JOINT PROTOCOLS

NAME OF PATIENT__________________________

Doctor__________________________ DOS / / DOI / /

Preoperative Diagnosis:____________________________________________________

Surgical Procedure:________________________________________________________

Surgical Complications:____________________________________________________

Age of Patient_____ Sex_____ Involved Side_____ Dominant Side_____ 

Occupational Injury Yes____ No____

Occupation__________________________

Sport Injury- Yes____ No____ Sport__________________________

Injury from other cause (please state):________________________________________

Position of Patella in Trochlear Groove__________________________
(Baja/Alta/Tilt)

HOSPITAL DISCHARGE

Date____ /____ /____ Protocol Title/Date__________________________

Check-off if complete:

_____ Pt. was given all protocol instructions prior to discharge.

_____ Pt. achieved all discharge parameters satisfactorily.

Alterations from protocol

PHASE TWO: (2ND WEEK)

Check one: Clinical Care_____ Home Program_____

Do you use: Cane_____ Crutches_____ Walker_____ Nothing required_____

Date____ Protocol Date____

Pain Scale________

Passive Extension_____

Active Extension_____

Passive Flexion_____

Active Flexion_____

Joint Effusion (measured mid patella)_____ cm.

Opposite Side_____ cm.

Satisfactory Quad Function - Yes____ No____

Patellar Mobility________ (include form)

Apprehension Present Yes____ No____

Complications/Comments:

Bilateral Measurements Taken: _______Yes _______No

Data Logged: _______Yes _______No # of Visits: _______
PHRASE THREE: (3RD WEEK)
Check One: Clinical Care Home Program
Do you use: Cane Crutches Walker Nothing Required
Date Protocol Date
Pain Scale
Passive Extension
Active Extension
Passive Flexion
Active Flexion
Joint Effusion (measured mid patella) cm.
Satisfactory Quad Function - Yes No
Patellar Mobility (include form)
Apprehension Present
Balance Test (include form)
Resisted Flexion at Six Weeks (MMT)
Complications/Comments:

Data Logged: Yes No # of Visits:

PHASE FOUR: (7TH WEEK)
Check One: Clinical Care Home Program
Do you use: Cane Crutches Walker Nothing Required
Date Protocol Date
Pain Scale
Passive Extension
Active Extension
Passive Flexion
Active Flexion
Joint Effusion (measured mid patella) cm.
Satisfactory Quad Function - Yes No
Patellar Mobility (include form)
Apprehension Present - Yes No

Manual Muscle Testing (Quadriceps)
5 Complete range of motion against gravity with maximum resistance
4 Complete range of motion against gravity with moderate resistance
3 Complete range of motion with gravity
2 Complete range of motion with gravity eliminated
1 Evidence of slight contraction, but no joint motion
0 No contraction palpated

Complications/Comments:

Data Logged: Yes No # of Visits:
### Phase Five: (10th Week)

Check one: Clinical Care  Home Program  
Date  Protocol Date  
Pain Scale  
Passive Extension  
Active Extension  
Passive Flexion  
Active Flexion  
Joint Effusion (measured mid patella) cm. 
Satisfactory Quad Function - Yes  No  
Patellar Mobility (include form)  
Apprehension Present - Yes  No  
Isokinetic Test Quadriceps and Hamstrings, (60, 180, & 300) (include short form) USE THESE SPEEDS FOR ALL OTHER TESTS  
Functional Tests (include form)  
Complications/Comments:  

<table>
<thead>
<tr>
<th>DATA LOGGED</th>
<th>Yes</th>
<th>No</th>
<th># of Visits</th>
</tr>
</thead>
</table>

### Six Months Post Surgery

Current Symptoms: (check each one that applies)  
- Pain Scale  Unusual Sounds  Joint Going Back In  
- Swelling  Joint Locking Up  Inability To Move  
- Stiffness  Joint Giving Way  
Passive Extension  
Active Extension  
Passive Flexion  
Active Flexion  
Patellar Mobility (include form)  
Apprehension Present - Yes  No  
Isokinetic Test Quadriceps and Hamstrings (include short form)  
Functional Tests (include form)  
Complications/Comments:  

<table>
<thead>
<tr>
<th>Functional Assessment</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Logged</td>
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<td>No</td>
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</tbody>
</table>

### One Year Post Surgery

Current Symptoms: (check each one that applies)  
- Pain Scale  Unusual Sounds  Joint Going Back In  
- Swelling  Joint Locking Up  Inability To Move  
- Stiffness  Joint Giving Way  
Passive Extension  
Active Extension  
Passive Flexion  
Active Flexion  

---
Patellar Mobility_______  Yes  No
Apprehension Present -______ Yes  No
Balance Test______ (include form)
Isokinetic Test______ (Quadriceps and Hamstrings) (include short form)
Functional Tests______ (include form)
Complications/Comments:

Functional Assessment:  Yes  No
Data Logged:  Yes  No

TWO YEARS POST SURGERY
Current Symptoms: (check each one that applies)
  Pain Scale_____ Unusual Sounds_____ Joint Going Back In____
  Swelling_____ Joint Locking Up_____ Inability To Move____
  Stiffness_____ Joint Giving Way____
Passive Extension_____
Active Extension_____
Passive Flexion_____
Active Flexion_____
Patellar Mobility_______ (include form)
Apprehension Present -______ Yes  No
Isokinetic Test______ (Quadriceps and Hamstrings) (include short form)
Functional Tests______ (include form)
Complications/Comments:

Functional Assessment:  Yes  No
Data Logged:  Yes  No

KA/MC/alr
5/96
LONGITUDINAL STUDY CONSENT FORM

THE RESULTS OF YOUR REHABILITATION PROCESS ARE BEING GATHERED AS PART OF A LONG TERM STUDY OF SURGICAL AND FUNCTIONAL OUTCOMES OF YOUR PARTICULAR DIAGNOSIS. ONCE YOU HAVE COMPLETED YOUR FORMALIZED PHYSICAL THERAPY TREATMENT AND HAVE BEEN DISCHARGED FROM ST. ALEXIUS MEDICAL CENTER, WE WOULD APPRECIATE THE OPPORTUNITY OF RETESTING YOUR STATUS AT 6 MONTHS, 12 MONTHS, AND 24 MONTHS POST DISCHARGE. THESE LAST THREE VISITS WOULD BE FREE OF CHARGE AND ALL RESULTS WOULD BE MADE READILY AVAILABLE TO YOU.

WHEN UNDERGOING THESE TESTS, THERE ARE CERTAIN INHERENT RISKS WHICH INCLUDE THE POSSIBILITY OF MUSCLE AND LIGAMENTOUS INJURY. YOU SHOULD EXERT YOUR BEST EFFORT THROUGHOUT THE EVALUATION BUT AT NO TIME ARE YOU EXPECTED TO EXPERIENCE ANY INCREASE IN PAIN OR DISCOMFORT BEYOND A LEVEL YOU FEEL YOU CAN COMFORTABLY TOLERATE. AT NO TIME WILL YOU BE FORCED TO PERFORM ANY TESTS WHICH YOU DO NOT WISH TO PERFORM AS YOU ARE IN CONTROL OF THE TESTING AND MAY STOP WHENEVER YOU FEEL THAT YOU SHOULD NOT PROCEED. IF WE SEE YOU EXERTING EFFORTS, WHICH IN OUR OPINION MAY PLACE YOU IN DANGER, WE WILL STOP YOU.

BASED ON THE ABOVE INFORMATION THAT I HAVE READ AND UNDERSTAND, I AGREE TO PARTICIPATE IN THIS LONGITUDINAL STUDY.

________________________
DATE

________________________
PARTICIPANT SIGNATURE
LOWER EXTREMITY RANGE OF MOTION MEASUREMENTS
NON-INVOLVED EXTREMITY

DATE: __________

(To be used on the first outpatient visit)

FOR HIP PATIENTS

Active Flexion, Supine______
Active Extension, Prone With Knee Flexed______
Active Internal Rotation With Knee and Hip Flexed, Sitting______
Active External Rotation With Knee and Hip Flexed, Sitting______

FOR KNEE PATIENTS

Active Flexion of the Knee, Prone_____
Active Extension of the Knee, Sitting_____
Patellar Mobility Sheet_____

FOR ANKLE PATIENTS

Active Plantar Flexion, Knee Extended, Sitting______
Active Plantar Flexion, Knee Flexed, Sitting______
Active Dorsiflexion, Knee Extended, Sitting______
Active Dorsiflexion, Knee Flexed 90 Degrees, Sitting______
Active Inversion, Supine, Knee Extended____
Active Eversion, Supine, Knee Extended____
NCSP______ STN DF Knee Flexed/Extended____
RCSP______ STN PF Knee Flexed/Extended____

Do You Use: Cane_____ Crutches_____ Walker_____
PATELLAR MOBILITY (Check one)

Medial Glide 50%

Greater than 50%  35% to 50%  Less than 35%

Lateral Glide 40%

Greater than 40%  25% to 40%  Less than 25%

Inferior Glide 40%

Greater than 40%  25% to 40%  Less than 25%

Superior Glide 25%

Greater than 25%  15% to 25%  Less than 15%

Patellar Baja/Alta: Patellar tendon length to patella (1:1 ratio)

Baja (20% less)  Alta (20% greater)

Patellar tilt or rotation (at 20 to 30 degrees of knee flexion)

Tilt  yes  No  Direction

Rotation  Yes  No  Direction
## LOWER EXTREMITY FUNCTIONAL ASSESSMENT FORM

**DATE:**

### NON-SPORT INJURY

<table>
<thead>
<tr>
<th>Activity</th>
<th>SATISFACTORY</th>
<th>NON-SATISFACTORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level Ground</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Stair Climbing - (up/down)</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>NA 5 4 3 2 1</td>
<td></td>
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</tbody>
</table>

### TRANSFERS

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<th>NON-SATISFACTORY</th>
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<tbody>
<tr>
<td>Toilet</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Tub</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Chair</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>NA 5 4 3 2 1</td>
<td></td>
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</table>

### DAILY ACTIVITIES

<table>
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<tr>
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<th>NON-SATISFACTORY</th>
</tr>
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<tbody>
<tr>
<td>Dressing</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td>NA 5 4 3 2 1</td>
<td></td>
</tr>
</tbody>
</table>

### SPORT INJURY

### COMPLETE GAIT FORM
## LOWER EXTREMITY
### FUNCTIONAL TEST FORM

**FOUR SQUARE TEST - SINGLE LEG**

<table>
<thead>
<tr>
<th></th>
<th>UNINVOLVED</th>
<th>INVOLVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 4</td>
<td>20 Seconds</td>
<td>____ Reps.</td>
</tr>
<tr>
<td>1 to 2</td>
<td>20 Seconds</td>
<td>____ Reps.</td>
</tr>
<tr>
<td>1 to 3</td>
<td>20 Seconds</td>
<td>____ Reps.</td>
</tr>
</tbody>
</table>

Are you able to:
- ____ Jog less than 7 blocks?
- ____ Run less than 7 blocks?
- ____ Jog greater than 7 blocks?
- ____ Run greater than 7 blocks?
- ____ Jog greater than 14 blocks?
- ____ Run greater than 14 blocks?

Can you cut with these or any activities? **Yes** ____ **No** ____

Do you need bracing support with any activity? **Yes** ____ **No** ____

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5/96
APPENDIX B
LATERAL RETINACULAR RELEASE
VASTUS MEDIALIS OBLIQUUS ADVANCEMENT PROTOCOL

AUGUST 1993

INDICATIONS
Patellofemoral Malalignment
Patellar Subluxations
Patellar Dislocations

PRECAUTIONS
Treatment of the post surgical patient must attend to the underlying cause for surgery and associated findings during arthroscopic examination as well as associated procedures performed.

Be Aware Of:
1. VMO advancement
2. Condition of femoral trochlear surface
3. Condition of retropatellar surface
4. Presence of chondroplasty

PHASE ADVANCEMENT
All exercises should be advanced based on the symptoms of the patient. Pain free exercise is the standard for advancement from one stage to the next. Times given for advancement are minimum times frames for the uncomplicated patient to allow for appropriate soft tissue healing constraints. Attention should be given to the response of the patellofemoral joint during the rehabilitation process and adjustments to be made according to this.
PATIENT EDUCATION

1. Review surgical procedure.
2. Caution patient about prevention of stress on the sutures for the first 6 weeks.
3. Caution patient about preventing maximal quadricep contractions until 6 weeks postoperative.

DISCHARGE GOALS

1. Normal ROM.
2. 90% quadricep strength and power with no extensor lag.
3. Return to preinjury/surgical activity level.

I. Phase I - Beginning Postop Day #1

A. Recovery Room
   1. Compression wrap with lateral felt horseshoe
   2. Cold Jobst with E-Stim over VMO

B. Immobilize in extension

C. Toe or foot touch weightbearing with crutches first 3 days progressed to 50% weightbearing by day #7

D. Submaximal quad sets with E-Stim

E. Resisted straight leg raises into hip extension and adduction with brace on

F. Hamstring/gastroc stretching

G. Active and resistive knee flexion to 60 degrees if comfortable

H. Patellar mobilization (superior, inferior, medial)

I. Continued compression wrapping

J. Cryotherapy - cold JOBST b.i.d. if possible or icing
LRR - VMO PROTOCOL
PAGE THREE

K. CPM as ordered by physician.

II. Phase II - Week #2

A. Allow limited motion as comfortable
B. Weightbearing as tolerated
C. Continue submax quad sets utilizing biofeedback for proper VMO function
D. Continue straight leg raise into hip extension and adduction with brace on
E. Begin multi-hip in adduction, abduction, flexion and extension
F. Active and resistive knee flexion to 90 degrees
G. Continue hamstring/gastroc stretching
H. Continue patellar mobilization
I. Active knee flexion in standing position
   1. Do submaximal quad sets when knee is extended
J. Biking when tolerated for range of motion with minimal resistance
K. Continue compression wrapping
L. Cryotherapy

III. Phase III - Week #6

A. Full weightbearing with no external support
   1. May use knee sleeve for comfort
LRR - VMO PROTOCOL
PAGE FOUR

B. Maximal quad sets with biofeedback over VMO
C. Straight leg raises in all planes
D. Pain free submaximal dynamic resisted knee extension
   1. Speed squats, lateral stepups, BAPS board, wall sits
   2. Submaximal leg press
   3. Versa-Climber and Stair Stepper
E. Maximum resistance dynamic knee flexion exercises through full arc
F. Continue hamstring/gastroc stretching
G. Active range of motion and general stretching (bike)
H. Continue patellar mobilization
I. Continue compressive wrapping
J. Cryotherapy
K. Treadmill gait training forward and backward walking on level ground progressing to 5-10% elevation

IV. Phase IV - Week #8
A. Maximal quad sets with continued VMO training
B. Continue straight leg raises
C. Maximum resistance dynamic quadriceps and hamstring strengthening exercises (emphasis on endurance)
D. Light jogging
   1. Plyometrics
      - Begin with light weight (<body weight) on supine leg press
LRR - VMO PROTOCOL
PAGE FIVE

- Progress to level ground plyometrics when at 70-80% strength compared to uninvolved side

- Progress to box jumps and resistance with sports cord for lateral stepups, lunges and single leg squats as function and strength improve

2. Continued BAPS, speed squats, and lateral stepups for proprioception

D. Continue hamstring/gastroc stretching

E. Active range of motion and vigorous stretching to regain normal range of motion

F. Functional training
   - Begin a retro-walking program with progression to incline retro-running
   - Increase retro-walking to 2% grade with progression to incline retro-running
   - Lateral shuffles, cariocas and rope jumping

G. Continue compressive wrapping

H. Cryotherapy

V. Phase V - Maintenance Program

A. Continued plyometric progression

B. Continued retro-walking/running program

C. Sports specific training

D. Continue strengthening program for six months after strength returns to discharge parameters.

MEDICAL REVIEWER SIGNATURE   MEDICAL DIRECTOR SIGNATURE

CLINICAL REVIEWER SIGNATURE   CLINICAL DIRECTOR SIGNATURE
BIBLIOGRAPHY


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LATERAL RETINACULAR RELEASE PROTOCOL

JUNE 1996

INDICATIONS

Patellofemoral Malalignment
Patellar Subluxations
Patellar Dislocations

PRECAUTIONS

Treatment of the post surgical patient must attend to the underlying cause for surgery and associated findings during arthroscopic examination as well as associated procedures performed.

Be Aware Of:

VMO advancement (separate protocol)
Condition of the femoral trochlear surface
Condition of the retropatellar surface
Presence of chondroplasty

All exercises should be advanced based on the symptoms of the patient. Pain free exercise is standard for advancement from one stage to the next. Times given for advancement are minimum time frames for the uncomplicated patient.

GOALS

1. Full knee flexibility
2. Good and symmetrical lower extremity balance/proprioception
3. Quadriceps/hamstring strength and endurance 80-90%+ involved to uninvolved.

4. Progressive return to full ADLs without associated patellofemoral pain and/or instability

I. Phase I - Acute Postoperative Phase (0-10 Days)

A. Weightbearing as tolerated with crutches
   
   1. Be aware of specific physician recommendations depending upon surgical technique.

B. AROM in pain free arc

C. Passive patellar mobility (superior, inferior, medial)

D. Thigh strengthening as per isometric setting exercises to quadriceps, hamstrings, and adductors (E-Stim utilized for enhanced VMO training as indicated)

E. Hamstring/gastroc stretching

F. Compressive wrapping, icing, and cold Jobst as indicated for effusion reduction.

II. Phase II - Semi-Acute Phase (7-21 Days)

A. Continue weightbear progression as tolerated

B. Continue range of motion activities with initiation of gentle stretching as indicated

C. Continue passive patellar mobilization

D. Continue open chain strengthening program as per isometric setting versus advancement to multi-hip SLR/Sportcord program as indicated

E. Initiation of functional closed chain strengthening
   - Leg press
   - Wall/quarter squats
   - Step training (lateral, forward, retro, etc.)
F. Initiation dynamic open chain hamstring strengthening

G. Continue hamstring and gastroc/soleus stretching

H. Continue compression and cryotherapy techniques for effusion reduction as indicated

III. Phase III - Non-Acute Phase (4-12 Weeks)

A. Continued knee flexibility program

B. Continued knee strengthening program with orientation towards functional sports specific training as indicated including:

1. Step training
2. Forward lunges
3. Leg press advancing from double to single leg
4. Treadmill retrograde walking
   - 10 to 20° angle for enhanced VMO training if possible

C. Endurance training activities as per biking, swimming, Stair-Stepper, walking, etc.

   1. Emphasize "sports specificity"

D. Quadriceps isotonics/isokinetics

   1. Avoid painful arc
   2. Submaximal loading to minimize patellofemoral stresses

E. Plyometrics(proprioceptive training

   1. Progressive advancement from static to dynamic training (BAPS versus single leg stance versus leg press routine versus floor jumping drills, etc.)

   2. Emphasize "sports specificity"

   3. Recommend 70-80% return of quad/hamstring strength and endurance before initiation of advanced plyometrics (i.e. box jumping, etc.)
SPECIAL CONSIDERATIONS:

A. McConnell taping
B. Patellar supports
C. Foot orthotics
BIBLIOGRAPHY

LATERAL RETINACULAR RELEASE


AB/arl
6/96
TIBIAL TUBERCLE TRANSFER PROTOCOL

INDICATIONS

A. Recurrent patellar subluxation or dislocation
B. Patellofemoral malalignment
C. Acute patellar dislocation

PRECAUTIONS

A. Allow 4-6 weeks bony healing of tibial tubercle
B. Aggressive rehab to patellofemoral joint should be avoided
C. Patellar baja is a frequent complication in Hauser procedure. Not in medial tibial tubercle transfer.

GOALS

A. Painless knee
B. Full active range of motion
C. 80-100% quad to quad ratio at discharge

CRITERIA FOR PHASE ADVANCEMENT

A. Time constraints for bony healing must be met prior to phase advancement.
B. Pain free exercise
TIBIAL TUBERCLE TRANSFER PROTOCOL
PAGE TWO

PATIENT EDUCATION

A. Clinical
   1. Anatomy
   2. Existing pathology
   3. Planned rehab

B. Pre-Op Instructions
   1. Anatomy
   2. Existing pathology
   3. Planned surgical technique:
      Open lateral retinacular release - tibial tubercle
      wedge osteotomy transfer medially and screw
   4. Post-op precautions
   5. Crutch gait
   6. Teach active resisted flexion and return to extension
      passively.

REHABILITATION SCHEDULE

Phase I - Beginning Post-Op Day #1 Through Week #2
   1. Toe/foot - touch weight bearing
TIBIAL TUBERCLE TRANSFER PROTOCOL
PAGE THREE

2. Hamstring/gastroc stretching
3. Passive knee extension
4. Submaximal resisted knee flexion 0-60 degrees
5. Gentle quad setting/standing knee extension (E-Stim to VMO if necessary beginning Week #2)
6. Modalities as needed for pain
7. Compression wrap
8. Cryotherapy

Phase II - Week #3

1. Partial weight bearing to one half body weight
2. Continue hamstring/gastroc stretching
3. Active knee extension to available range without resistance
4. Continued resisted knee flexion, increasing flexion as tolerated.
   a. Begin isometric hip adduction when flexion is at 90 degrees actively.
5. Continue quad setting/standing knee extension (E-Stim over VMO).
6. Begin straight leg raises (emphasis on flexion and adduction: E-Stim over VMO)
TIBIAL TUBERCLE TRANSFER PROTOCOL

PAGE FOUR

8. Biking as tolerated for range of motion and patellofemoral joint rehab.

9. Modalities as needed for pain

10. Compression wrap

11. Cryotherapy

Phase III - Week #4

1. Progressive weight bearing to full

2. Continue hamstring/gastroc stretching

3. Continue active range of motion until full

4. Continue straight leg raises

5. Begin with lateral stepups start with 2 inch steps

6. Bilateral leg press

7. Retrograde walking 0-10% elevation

8. Continue cryotherapy

9. Versa Climber 4-6 inch steps beginning Week #5

Phase IV - Week #6 Until Discharge

1. Full weight bearing should be achieved.

2. Continue hamstring/gastroc stretching

3. Emphasis on endurance training
   a. Isokinetics at high speed
   b. Isotonic - May begin full arc quad exercises dictated by response of patellofemoral joint.
TIBIAL TUBERCLE TRANSFER PROTOCOL

PAGE FIVE

4. Functional training (Advance plyometrics, BAPS board, etc.)

5. Sportscord resisted lateral stepdown lunge, single leg squats, single leg pushes add resistance as tolerated with Sportscord. Retrograde walking 10-30% elevation. Plyometrics beginning on level surfaces. Single leg on Stairstepper. Add back pedal at 8 weeks utilizing higher elevations.

6. Swimming

E. Phase V - Maintenance

1. Lower extremity flexibility program

2. Lower extremity program with particular emphasis on quad musculature.

CLINICAL DIRECTOR SIGNATURE

CLINICAL REVIEWER SIGNATURE

MEDICAL DIRECTOR SIGNATURE

MEDICAL REVIEWER SIGNATURE

MD/air
Reviewed 9/1991
Revised 7/30/93
Revised 8/24/93
BIBLIOGRAPHY

Hanson, J.; Gruby, R.S., Tibial Tubercle Transfer, I.S.M. Library, St. Alexius Medical Center, Bismarck, North Dakota, September 1991.


MANGINE, Robert; Conference: The Knee, A Clinical Approach, November 5-6, 1988 Grand Forks, North Dakota.

I. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.)

With the rise in health care costs, medical professionals have moved from a fee-for-service to a highly competitive, cost-conscious environment of managed care. Physical therapists as members of the medical community are certainly not exempt, being held accountable for treatment efficacy as well as the achievement of functional outcomes. It is these outcomes which may be used to determine treatment effectiveness while providing a basis for third party reimbursement.

This research study is being performed to assist not only St. Alexius Medical Center of Bismarck, ND, but to assist all health care providers with the information as to effective post-surgical treatment of patellar-femoral pain. Specific procedures examined will include patients who have undergone lateral retinacular release, tibial tubercle transfer, or vastus medialis muscle advancement. As part of the standard rehabilitation
process, St. Alexius physical therapists examined patients at specific pre-determined intervals, recording various measurements. This study is intended to examine the recorded data to determine treatment effectiveness as well as patient’s functional outcomes. Results of this study will be useful to clinician as well as third party reimbursement agencies.

\textbf{PLEASE NOTE:} Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

\textbf{I. PROTOCOL:} (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

This outcome study is being performed as a chart review to determine the effectiveness of physical therapy treatments with the following surgical procedures: lateral retinacular release, tibial tubercle transfer, and vastus medialis muscle advancement. A copy of the data collection sheet has been included (Addendum 1). At predetermined intervals, a variety of standard clinical measurements were collected by St. Alexius physical therapists, to help determine patients’ rehabilitation status at two weeks, three weeks, seven weeks, ten weeks, six months, one year and two years post surgery. Questions which we will attempt to answer include but are not limited to the following:

1. At predetermined intervals, is there a significant difference in strength between patients who received differing surgical procedures?
2. Is there a significant difference noted when comparing range of motion measurements of open vs. laser procedures for the lateral retinacular release?
3. Is there a significant difference in the number of visits necessary for each procedure to demonstrate a return of functional range of motion?
4. Concerning age, is there a significant difference in results for range of motion and function attained after surgery?
5. Are patients of each procedure able to attain satisfactory functional results as pre-described in the outcome study form upon completion of therapy?
6. Are patients able to demonstrate 90\% quadriceps strength and power when comparing the uninvolved versus involved knee upon discharge?
7. Are patients of each procedure studied able to demonstrate pain free, functional range of motion at discharge? Is one more significant than the other(s) ?

Patient participation in this study was based upon selection of St. Alexius as the exclusive provider of surgical and rehabilitation care. Patient cooperation for data collection was done on a voluntary basis following agreement of the attached consent form (Addendum 2). Minor consent for participation in this study will also be covered by St. Alexius Medical Center through their signing of a consent form upon beginning therapy.

Traditional statistical analysis will be used to describe and analyze results of information utilized by this study.

\textbf{3. BENEFITS:} (Describe the benefits to the individual or society.)
Patients in this study will knowingly not benefit directly from its results. However, results will provide the clinician with the tools necessary to improve treatments and have sound resources for treatment and planning, improving all future patient care. These improvements will not only result in greater cost-efficiency for patients with patellar femoral dysfunction, but will provide physical therapists with a rationale for third party reimbursement. It will be of great benefit to the realm of professional physical therapists, allowing them to modify treatments if necessary or provide them with justification that what they are doing is effective for patient treatment.

RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

Collection of data by St. Alexius physical therapists was performed on a voluntary basis during standard patient rehabilitation. Confidentiality will be reserved by inserting patient data with the use of arbitrary codes assigned to each patient with no known relevance to the patient. Results will not be individually reported, but rather they will be derived from compiled data.

5. CONSENT FORM: A copy of the CONSENT FORM to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no CONSENT FORM is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur. Describe where signed consent forms will be kept and for what period of time.

Consent forms for participants, including adults as well as minors, were gathered by staff at St Alexius Medical Center and will be kept within their facility (Addendum 3). No additional consent forms will be utilized for this study. A letter of agreement from St. Alexius Medical Center for inclusion of this study and the use of patient data is also attached (Addendum 4).

5. For FULL IRB REVIEW forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Grand Forks, North Dakota 58202-7134

On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

For EXEMPT or EXPEDITED REVIEW forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.
SIGNATURES:

Principal Investigator

Project Director or Student Adviser

Training or Center Grant Director

Date

Date

Date

(Revised 3/1996)
STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your "Human Subjects Review Form."

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit. The study to which this release pertains is Outcome Study of Physical Therapy Rehabilitation of Patients with Patellar Femoral Dysfunction.

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that this policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

________________________  ________________________
Date                     Signature of Student Researcher

1Consent required by 20 U.S.C. 1232g.
APPENDIX D
LONGITUDINAL OUTCOME STUDIES

A longitudinal outcome study was set up for a variety of diagnoses, specifically surgical procedures September 1, 1995 by St. Alexius Medical Center and the Institute of Sports Medicine. Outcomes, specific to physical therapy, have been set up to be followed up for two years post surgery. The studies monitored will include those individuals who have undergone the following surgical procedures: Achilles tendon repair, ACL reconstruction, Bankart repair, biceps tendon repair, Brostrom reconstruction, capsular shift, patellofemoral joint surgery, as well as rotator cuff repair. All subjects are notified of the study and will have a consent form filled out specifically when they go beyond the normal insurance reimbursable time table. Please note that under no circumstances, subjects will be exposed to any procedure or test which is beyond the normal protocol.

Data compiled with the outcome studies will be kept within the Institute of Sports Medicine as well as original copies of specific tests during the normal rehab kept within the medical records department at St. Alexius Medical Center. The Bone & Joint Center will also be offering assistance in terms of the actual surgical procedures.

This letter is to notify those institutions which will be assisting in helping to compile this outcome data that individuals are fully aware of their participation in the study, and again, will be put at no risk other than the normal rehab procedures during the compiling of this data. If any questions, please call Kevin Axtman at 1-800-222-7858, assistant director at the Human Performance Center, also Doug Bradford, director of Rehab Services at St. Alexius Medical Center at 1-701-224-7189, or Myron Cullen, assistant director at the Human Performance Center at 1-800-222-7858.

Kevin Axtman, PT/LATC
Doug Bradford, PT
Director of Rehab Services

Richard A. Pschider, FACHE/CEO
St. Alexius Medical Center

"Let all be received as Christ."
The above referenced project was reviewed by a designated member for the University's Institutional Review Board on March 16, 1999 and the following action was taken:

☐ Project approved. EXPEDITED REVIEW NO. _______________________.
Next scheduled review is on _______________________.

☐ Project approved. EXEMPT CATEGORY NO. ________, No periodic review scheduled unless so stated in the Remarks Section.

☐ Project approved PENDING receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. This study may NOT be started UNTIL final IRB approval has been received. (See Remarks Section for further information.)

☐ Project approval deferred. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project denied. (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

PLEASE NOTE: Requested revisions for student proposals MUST include adviser's signature.
APPENDIX F
THE RESULTS OF YOUR REHABILITATION PROCESS ARE BEING GATHERED AS PART OF A LONG TERM STUDY OF SURGICAL AND FUNCTIONAL OUTCOMES OF YOUR PARTICULAR DIAGNOSIS. ONCE YOU HAVE COMPLETED YOUR FORMALIZED PHYSICAL THERAPY TREATMENT AND HAVE BEEN DISCHARGED FROM ST. ALEXIUS MEDICAL CENTER, WE WOULD APPRECIATE THE OPPORTUNITY OF RETESTING YOUR STATUS AT 6 MONTHS, 12 MONTHS, AND 24 MONTHS POST DISCHARGE. THESE LAST THREE VISITS WOULD BE FREE OF CHARGE AND ALL RESULTS WOULD BE MADE READILY AVAILABLE TO YOU.

WHEN UNDERGOING THESE TESTS, THERE ARE CERTAIN INHERENT RISKS WHICH INCLUDE THE POSSIBILITY OF MUSCLE AND LIGAMENTOUS INJURY. YOU SHOULD EXERT YOUR BEST EFFORT THROUGHOUT THE EVALUATION BUT AT NO TIME ARE YOU EXPECTED TO EXPERIENCE ANY INCREASE IN PAIN OR DISCOMFORT BEYOND A LEVEL YOU FEEL YOU CAN COMFORTABLY TOLERATE. AT NO TIME WILL YOU BE FORCED TO PERFORM ANY TESTS WHICH YOU DO NOT WISH TO PERFORM AS YOU ARE IN CONTROL OF THE TESTING AND MAY STOP WHENEVER YOU FEEL THAT YOU SHOULD NOT PROCEED. IF WE SEE YOU EXERTING EFFORTS, WHICH IN OUR OPINION MAY PLACE YOU IN DANGER, WE WILL STOP YOU.

BASED ON THE ABOVE INFORMATION THAT I HAVE READ AND UNDERSTAND, I AGREE TO PARTICIPATE IN THIS LONGITUDINAL STUDY.

DATE ________________________________________________________

PARTICIPANT SIGNATURE ________________________________________

900 East Broadway  Box 5510
Bismarck, North Dakota 58502-5510
701 224-7000
FAX 701-224-7284
TDD 701-224-7946
REFERENCES


