

**THE RELATIVE EFFECTIVENESS OF COMBINED  
“ACTION POTENTIAL THERAPY” AND PATELLA  
MOBILIZATION VERSUS COMBINED PLACEBO “ACTION  
POTENTIAL THERAPY” AND PATELLA MOBILIZATION  
IN THE TREATMENT OF PATELLOFEMORAL PAIN  
SYNDROME.**

by

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A dissertation submitted to the Faculty of Health in partial compliance with the requirements  
for a Master's Degree in Technology: Chiropractic at Technikon Natal.

I, Jenifer Ann Goldberg do hereby declare that this dissertation represents my own work in  
both conception and execution.

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Date

## DEDICATION

This work is dedicated to three special people:

Ann Goldberg for supporting me unconditionally throughout my life and studies.

Marie' Broodryk for all our "chats", for being my best friend and for always being an angel.

Simon Bellingham for sharing this journey with me and for providing endless hours of love  
and laughter.

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## ABSTRACT

The purpose of this study was to determine the relative effectiveness of combined Action Potential Therapy (APT) and patella mobilization versus combined patella mobilization and placebo Action Potential Therapy in the treatment of Patellofemoral Pain Syndrome.

The study was a prospective, randomized, placebo controlled study. The study involved 60 subjects, 30 in each group which were selected from the general population. Group one received patella mobilization and APT while group two received patella mobilization and placebo APT. Patients received four treatments over a period of two weeks. The first treatment consisted of patella mobilization and APT (group one) or patella mobilization and placebo APT (group two), treatment 2,3 and 4 consisted of APT (group one) or placebo APT (group two).

Subjective assessment was by means of the short form Mc Gill pain Questionnaire, Numerical Pain Rating Scale - 101 Questionnaire and the Patient Specific Functional Scale. Objective assessment of tenderness was by means of an algometer. Assessments were taken on the first, second and fifth consultations for all subjective and objective measures.

Statistical analysis was completed under the supervision of Dr Myburgh at Technikon Natal, at a 95% confidence interval. The parametric two-sample paired t-test and the non-parametric Wilcoxon signed rank tests were used to analyze data within each group, while the parametric

two-sample unpaired t-test and non-parametric Mann-Whitney unpaired U test were used to analyse the data between each group.

In terms of objective findings both groups showed a significant overall increase in pressure pain threshold (algometric readings).

In terms of patients' subjective response to treatment, both groups showed a significant overall decrease in pain perception (NRS-101 and McGill Pain Questionnaire) and knee pain and disability (Patient Specific Functional Scale).

The treatment group showed a significantly greater improvement in objective findings (algometric measurements) at the final consultation.

It was concluded that patella mobilization and "Action Potential Therapy" was effective in the treatment of pain and dysfunction in patients with Patellofemoral Pain Syndrome, but only more so than patella mobilization and placebo "Action Potential Therapy" in terms of objective clinical findings.

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**ABBREVIATIONS USED IN CHAPTER FOUR**

Alg	- Algometer
APT	- Action Potential Therapy
McGill	- Short form Mc Gill pain questionnaire
Me.	- Mean
NRS-101	- Numerical pain rating scale-101
PSFS	- Patient specific functional scale
P-value	- Level of significance
Sd.	- Standard deviation
Se.	- Standard error



## DEFINITION OF TERMS

**Action Potential** is the propagation of a nerve impulse (Guyton, 1992: 47).

**Algometer** is an instrument that measures the patients' sensitivity to pressure in terms of kilograms per square centimetre (Fishcer, 1986).

**Action Potential Therapy** is a low-frequency current that simulates or mimics the naturally occurring action potential in a neuron. It is applied to the affected area via electrodes and is associated with pain alleviation, enhanced joint flexibility, a decrease in oedema due to improved circulation and possibly, reduced inflammation (Berger, 1999:11).

**Mobilization** is defined as passive therapeutic movement within the joint up to but not exceeding, the passive end range of movement (Turchin and Mootz, 1995).

**Objective clinical findings** for the purpose of this study are those findings obtained from recording the patients' pressure-pain threshold using an algometer.

**Pain threshold** is the minimum pain inducing pain or discomfort (Fischer, 1987).

**Patellofemoral Pain Syndrome (PFPS)** is defined as anterior knee pain arising from dysfunction of the patellofemoral articulation, including its connective and contractile tissues (Puniello, 1993).

**Placebo** is defined as a dummy treatment administered to the control group in a controlled clinical trial in order that the specific and non-specific effects of the experimental treatment can be distinguished (Dorland and Newman, 1988: 1299). For the purpose of this study the placebo therapy was the application of non active Action Potential Therapy.

**Subjective clinical findings** for the purpose of this study are those findings obtained from the subject in response to the NRS-101, the short form McGill Pain Questionnaire and the Patient Specific Functional Scale.

## CHAPTER ONE: INTRODUCTION

### 1.1 THE PROBLEM AND ITS SETTING

Patellofemoral Pain Syndrome (PFPS) is defined as anterior knee pain arising from dysfunction of the patellofemoral articulation, including its connective and contractile tissues (Puniello, 1993).

The condition presents as retro or peri patellar pain and crepitation during activities such as running, jumping, squatting and going up and down stairs. Once started it often becomes chronically painful forcing the patient to stop sports and related activities (Kannus and Niittymaki, 1993).

The term Patellofemoral Pain Syndrome was chosen for this study as it is descriptive, identifies the condition as a syndrome and is non assumptive (Meyer et al. 1990). However, the condition has also been referred to as patellalgia, gonalgia paraesthetica, anterior knee pain syndrome, retropatellar arthralgia, patellar tracking problem and the peripatellar syndrome (Reid, 1996:349).

It is the opinion of Walsh and Helzer-Julin (1992) that extensor mechanism disorders are the most common of all knee injuries presenting to the typical physicians' office, although it is not stated to which countries they are referring, the author presumes it is the United States as this was where the article was produced. Pinshaw, Atlas and Noakes (1984) reported that of 196

consecutive injuries seen in a runners' clinic the knee was the most common site of injury, accounting for 44% of all injuries, 50% of which were due to PFPS. During a five year period 22% of 2519 injuries reviewed at a sports injury clinic were knee injuries with 25% of the knee injuries being PFPS. In 32% of these cases running was thought to be a major cause (Devereaux and Lachmann, 1984).

Lateral retinaculum tightness is cited as a cause of chronic strain, inflammation, pain and aberrant patellofemoral tracking is considered an important patho-mechanical cause of PFPS. (Fulkerson, 1982). Mobilization of the patella can reduce lateral retinacular tension and may diminish synovial impingement by the odd facet (Wood, 1998). Chiropractors regularly treat PFPS. (Wood, 1998), mobilization of the patella being one of the most commonly applied treatments.

BenEliyahu (1992), Dryburgh (1988), Chadwick (1987), Fulkerson and Shea (1990), Linsheng (1991) and Turchin and Mootz (1995) have described mobilization of the patellofemoral joint as part of a conservative treatment protocol.

Many forms of patella and knee manipulative techniques have been described as part of a therapeutic protocol for PFPS, according to Souza (1990) these techniques all strive to restore accessory motion to the knee joint and disrupt scar formation.

PFPS although common and clinically significant in chiropractic practice, remains a difficult

and frustrating condition for the clinician to treat with permanent relief of symptoms often not being achieved (Reid, 1996:349). Conservative treatment is still in its infancy and relatively little research has been conducted on the various options of conservative treatment. Enthusiasm for medical therapy (Non-steroidal anti-inflammatories) has waned (Reid, 1996:349). The side effects and contra indications of this therapy being numerous (Snyman and Pope, 1998:48-61). With the above in mind it is important to investigate therapies that may augment mechanical treatment and provide a more comprehensive and effective treatment protocol.

A new low frequency electrical current therapy "Action Potential Current Therapy", developed in 1992 has been used by both the lay public and the health professional as a stand alone treatment since 1994 (Berger, 1999: 11). The current emitted by the Action Potential unit causes cycle synchronous depolarisation of nerve fibres and claims have been made that this current used as therapy may provide the amelioration of a number of therapeutic problems. It is believed that Action Potential Therapy may be useful in pain management, to restore mobility to stiff joints and muscles, to reduce swelling, to relieve tension and to improve blood circulation and lymphatic drainage (De Wet and Oosthuizen, 1997)

## 1.2 AIM OF THE STUDY

The aim of this study was to evaluate the relative effectiveness of combined patella mobilization and "Action Potential Therapy" versus combined patella mobilization and placebo "Action Potential Therapy" in the treatment of Patellofemoral Pain Syndrome.

## 1.3 OBJECTIVES OF THE STUDY

1.3.1 The first objective was to determine the relative effectiveness of patella mobilization and “Action Potential Therapy” versus patella mobilization and placebo “Action Potential Therapy” in the treatment of Patellofemoral Pain Syndrome, in terms of objective measures.

1.3.2 The second objective was to determine the relative effectiveness of patella mobilization and “Action Potential Therapy” versus patella mobilization and placebo “Action Potential Therapy” in the treatment of Patellofemoral Pain Syndrome, in terms of subjective measures.

## 1.4 HYPOTHESES

### 1.4.1 HYPOTHESIS ONE

It was hypothesised that combined patella mobilisation and “Action Potential Therapy” would be effective in decreasing pain and disability in patients with Patellofemoral Pain Syndrome.

### 1.4.2 HYPOTHESIS TWO

It was hypothesised that patella mobilisation and “Action Potential Therapy” would be more effective than placebo “Action Potential Therapy” in the management of patients with Patellofemoral Pain Syndrome.

## 1.5 BENEFITS OF THE STUDY

Meyer et al.(1990) stated that by knowing which of the conservative approaches to PFPS are more beneficial, some of the trauma, costs and complications of surgical intervention may be ameliorated.

Action Potential therapy may be useful as an adjunct to manual therapy in pain management and has the potential of becoming an important auxiliary modality in chiropractic care. The use of Action Potential Therapy as an adjunct to manual therapy is however, at present, based largely on anecdotal information rather than randomised controlled clinical trials.

It is hoped that this investigation will add to the pool of knowledge regarding a conservative treatment protocol for Patellofemoral Pain Syndrome.

## CHAPTER TWO: LITERATURE REVIEW

### 2.1 INTRODUCTION

The patellofemoral joint has posed many unsolved mysteries and challenges in the medical community and has been documented in the literature for almost 2 centuries, it has had volumes of literature published on theories and potential solutions to improve symptoms related to this troublesome joint (Kolwich et al. 1990).

The patellofemoral joint is a major source of pain and dysfunction in both men and women and in the sedentary and athletic population alike (Walsh, 1992). It has been referred to as a myth, mystical and frustrating and an enigma that remains a difficult condition to treat (Reid, 1993).

Patellofemoral pain syndrome (PFPS) is defined as anterior knee pain arising from the dysfunction of the patellofemoral articulation including its connective and contractile tissues (Puniello, 1993). Other terms used to describe this condition are patellagia, gonalgia paraesthetica, anterior knee pain syndrome, retropatellar arthralgia, patellar tracking problem and the peripatellar syndrome (Reid, 1996:349).

### 2.2 EPIDEMIOLOGY

Extensor mechanism disorders have been cited as the most common of all knee injuries presenting to the typical physician's office in the United States (Walsh and Helzer-Julín,



1992).

During a five year period 22% of 2519 injuries reviewed at a sports injury clinic were knee injuries with 25% of the knee injuries being PFPS. In 32% of these cases running was thought to be a major cause (Devereaux and Lachmann, 1984).

Out of 446 pupils randomly selected from a comprehensive school of 1850 pupils 136 had suffered knee pain in the previous year, 129 of which showed features of PFPS (Fairbank et al. 1984).

In a cross section by Galanty et al. (1994) of 142 high school students 45% had anterior knee pain on examination.

Pinshaw, Atlas and Noakes (1984) reported that of 196 consecutive injuries seen at the University of Cape Town SAB Sports Injury Clinic the knee was the most common site of injury, accounting for 44% of injuries, 50% of which were due to PFPS.

## 2.3 BIOMECHANICS OF THE PATELLOFEMORAL JOINT

The patella has the primary function of increasing the efficiency of the quadriceps muscle by increasing its lever arm. Two forces act on the patella during knee movement, the patellofemoral compression force and the quadriceps muscle tension force (Outerbridge and Dunlop, 1975).

The patellofemoral joint reaction force or the patellofemoral compression force is a measurement of compression of the patella against the femur and depends on the angle of flexion of the knee as well as upon muscle tension (Hungerford and Lennox, 1983).

The quadriceps muscle tension force and patellofemoral joint reaction force were investigated by Reilly and Martens (1972). The results demonstrated that:

- 1) The patellofemoral joint reaction force is always smaller than the quadriceps muscle force during level walking. The highest value for patellofemoral joint reaction force was at the level of 0.5 times body weight.
- 2) During stair walking the patellofemoral joint reaction force reached a level of 3.3 times body weight or 7 times the value of patellofemoral joint reaction force during walking.
- 3) Quadriceps exercises done by extending the knee from 90 degrees of flexion against 9kg resistance lead to a patellofemoral joint reaction force of 1.4 times body weight. The straight leg raise exercise done against the same resistance lead to a patellofemoral joint reaction force of 0.5 times body weight.

This possibly explains why the patient with PFPS is more disabled for stair walking and the retropatellar pain experienced with resisted knee extension exercises.

Goodfellow, Hungerford and Zindel (1976) delineated the patellofemoral contact areas using a dye technique. Patellofemoral contact first occurs at 10 to 20 degrees of knee flexion along the inferior patellar margin in a narrow continuous band. With increasing flexion the contact area moves proximal and becomes broader, extending from the medial to the lateral facet,

excluding the odd facet until after 90 degrees of flexion at which point the odd facet contacts the lateral margin of the medial condyle.

## 2.4 ANATOMY

The patella is a triangular sesamoid bone with its apex pointing inferiorly. The patella is embedded in the quadriceps femoris tendon with the patellar ligament (ligamentum patella) attaching the patella to the tibial tuberosity. This bone is subcutaneous and easily palpable, it lies anterior to the distal femur articulating with the condyles of the femur. The patella is thought to increase the power of the quadriceps femoris muscle by increasing its leverage (Moore, 1992:388). Reid (1996:345) states that the patella is across all sports and all ages probably the single most common cause of pain.

At the proximal end of the patella the quadriceps tendon inserts into the patella. The anatomy of the quadriceps muscle is described by Moore (1992:387). The quadriceps muscle is divided into four components: the rectus femoris, vastus lateralis, vastus medialis and vastus intermedius. This muscle is innervated by the femoral nerve and serves mainly to extend the leg. The anatomical origins are described as follows:

<b>Rectus femoris (RF):</b>	Anterior inferior iliac spine and groove superior to the acetabulum
<b>Vastus lateralis (VL):</b>	Greater trochanter and lateral lip of linea aspera of femur
<b>Vastus medialis (VM):</b>	Intertrochanteric line and medial lip of linea aspera of femur
<b>Vastus intermedius (VI):</b>	Anterior and lateral surfaces of body of femur.

The distal attachment is to the base of the patella via the quadriceps tendon.

The common direction of pull of the muscle fibers are as follows:

RF : 7 to 10 degrees medially in the frontal plane,

VL : 12 to 15 degrees laterally in the frontal plane,

VM longus (VML) : 15 to 18 degrees medially in the frontal plane and

VM obliquus (VMO) : 50 to 55 degrees medially in the frontal plane (Lieb and Perry, 1968).

It was found in a study on 6 cadavers that each muscle alone with sufficient tensile force in the direction of the normal muscle could produce extension at the knee with the exception of VM obliquus (Lieb and Perry, 1968).

In a prospective study on 34 cadaveric knees Bose et al. (1980) found that the VMO muscle originated partially from the adductor longus and magnus tendons as well as from the medial inter muscular septum with the maximum number of fibers arising from the adductor magnus tendon. The disposition of the fibers were oblique or transverse.

There is naturally a lateral pull on the patella due to the physiologic valgus of the knee and the Q angle of the quadriceps, the patella is stabilized against this lateral pull by the bony contour of the lower end of the femur and by the VMO. The patella articular surface on the lateral femoral condyle is raised, this offers stability to the patella especially when the knee is flexed. However, in the last 30 degrees of knee extension, the patella sits above the patella articular surface of the femur with little stability then offered by these bony contours. The VMO

becomes the most important structure in providing stability for the patella in the last 30 degrees of extension (Bose et al. (1980).

The medial retinacular fibers interdigitate with the superficial medial collateral ligament and the medial patellar tendon. The superficial oblique fibers of the lateral retinaculum run from the superficial aspect of the iliotibial band to the patella and blend with the quadriceps extension over the patella. The deep transverse fibers of the lateral retinaculum are much denser and deeper. The proximal end of the deep lateral retinaculum interdigitates with the vastus lateralis insertion into the patella forming the epicondylopatellar band. At the midpoint of the patella deep transverse fibers run from the iliotibial band directly into the patella. Distal to the dense transverse fibers more oblique fibers run from the distal lateral patella to the tibial tuberosity forming the patellotibial component of the deep lateral retinaculum (Fulkerson1989).

In a study on 8 cadavaric knees it was found that the retinaculum and patellar ligament had the highest free nerve ending count when compared to 16 other structures found in the knee. This indicates their importance in balancing the patella in the gliding mechanism (Biedert et al. 1992).

## 2.5 AETIOLOGY

The aetiology of PFPS is controversial and difficult to identify.

Devereaux and Lachmann (1984) in a study on PFPS in athletes attending a sports clinic found that of the 137 athletes presenting to the clinic with PFPS over a 5 year period actual patella trauma occurred in only 29% of athletes. This indicates that patella trauma does not appear to be a major contributing factor in the production of PFPS.

Fairbank et al. (1984) demonstrated that joint mobility, Q angle, genu valgum and anteversion of the femoral neck were not significantly different in adolescents that were with and without knee pain. In this study it was concluded that chronic overloading, rather than faulty mechanics was dominant in the etiology of anterior knee pain in adolescents. The study took place in two parts, the first concerned 446 pupils randomly selected, 136 of whom had suffered knee pain in the previous year with the second concerning 52 hospital outpatients with knee pain.

- ✓ During a five year period 22% of 2519 injuries reviewed at a sports injury clinic were knee injuries with 25% of the knee injuries being PFPS. In 32% of these cases running was thought to be a major cause (Devereaux and Lachmann, 1984). Pinshaw, Atlas and Noakes (1984) reported that of 196 consecutive injuries seen in a runner's clinic the knee was the most common site of injury, accounting for 44% of injuries, 50% of which were due to PFPS. These studies support the idea that chronic overloading may be a possible factor contributing to PFPS. It must be noted that the term "Runners knee" is PFPS.

Galanty, Matthews and Hergenroeder (1994) examined 142 adolescents. Measurements taken

were of quadriceps girth, Q angle, lower extremity flexibility and limb length. No relationship was found between these intrinsic factors and the diagnosis of anterior knee pain.

Thomee et al. (1995) evaluated 40 women with PFPS and 20 healthy controls. It was found that no significant difference could be found between the patients' most and least symptomatic knee, nor between the patients and the controls regarding clinical lower extremity alignment such as Q angles, leg heel alignment measures, pelvic width, knee hyper extension and distance between the knees. There were no radiographic signs of malalignment. The patients were found to be considerably more involved in sports than the controls. This agreed with Fairbank (1984) who found that pupils with symptoms from the patellofemoral joint enjoyed sporting activities significantly more than there symptom free classmates.

Shellock et al. (1989) used kinematic MRI to assess malalignments of the patella. Sequential axial images of the patellofemoral joint were taken during the early increments of passive knee flexion. Two hundred and thirty five symptomatic joints and 14 asymptomatic joints were examined. Normal patella tracking was observed in all of the asymptomatic subjects and in 17% of the symptomatic subjects. Normal alignment is when the apex of the patella is aligned with the femoral trochlea in such a way that the medial and lateral facets articulate with their counterparts on the femur and there is no transverse deviation of the patella during flexion from 5 to 30 degrees.

Malalignments were as follows:

**Lateral subluxation:** The apex of the patella is laterally displaced relative to the femoral trochlear groove or the centermost part of the femoral trochlea, and the lateral facet overlaps the lateral aspect of the patella, 26%.

**Excessive lateral pressure syndrome:** The lateral facet of the patella is tilted toward the lateral aspect of the femoral trochlea with little or no lateral subluxation of the patella, 8%

**Medial subluxation:** The apex of the patella is medially displaced relative to the femoral trochlea groove or centermost part of the femoral trochlea, 41%.

**Lateral to medial subluxation of the patella:** The patella starts in laterally displaced position and moves to a medially displaced position with increasing knee flexion, 7%.

**Dislocation:** The patella is completely displaced from its normal position relative to the femoral trochlea groove or the centermost part of the femoral trochlea, 2%.

This would suggest that abnormal patellofemoral joint mechanics would contribute to the aetiology.

Inappropriate neural control of the quadriceps muscle has been implicated in PFPS. Karst and Willet (1995) in their study "Onset Timing of Electromyographic Activity in the VMO and the VL Muscles in Subjects With and Without PFPS" found that differences in the relative timing of onset EMG activity of the VL and VMO during voluntary extension was not significant



between symptomatic and asymptomatic groups. They concluded that their results did not support the idea that altered timing of muscle activity played a role in PFPS. This was a controlled, prospective trial consisting of 15 symptomatic and 12 asymptomatic patients.

Abnormal lateral tracking has been a suggested cause of PFPS. A commonly suggested mechanism is an imbalance in the activity of the vastus medialis obliquus muscle (VMO) relative to the vastus lateralis muscle (VL). Souza and Gross (1991) in a comparative study on 16 patients found when comparing the VMO:VL integrated electromyographic (IEMG) ratios of healthy subjects and patients with PFPS that patients with PFPS had lower VMO:VL IEMG ratios, suggesting that abnormal muscle activation patterns may interact with biomechanical in explaining the cause of PFPS. This suggests an extensor mechanism dysfunction.

Reid (1996: 386-387) states that the presence of pain, effusion, or both in the knee joint reflexively inhibits quadriceps activity, particularly that of the VMO. He believes that this is reflected clinically with the onset of patellofemoral symptoms after a traumatic injury of the knee such as a ligamentous rupture and meniscal lesions.

## 2.6 PHYSICAL FINDINGS

Three physical findings have been found to be fairly specific for PFPS when the symptomology originates from the patellofemoral articulation:

- 1) palpation of the medial or lateral facets on the posterior surface of the patella may reveal tenderness (this examination is facilitated by displacing the patella medially or laterally whilst

palpating the undersurface),

2) compression of the patella onto the femoral condyles may produce characteristic discomfort and

3) when both sides of the patella are grasped whilst the quadriceps muscle is actively contracted, the augmented pressure of the patella against the femoral condyles may cause discomfort. This must be done repeatedly, gradually and bilaterally with an increase in discomfort in the symptomatic knee necessary for a positive finding.

If the source of pain is periarticular careful examination of the retinaculum and patella tendon is important as these structures may reveal the source of pain. If on examination the retinaculum is found to be consistently painful, relief of pain after injection of a small amount of anaesthetic into the area can confirm an extra articular source of the pain (Davidson, 1993).

Fulkerson (1983) demonstrated in a prospective study of 78 knees in 60 patients with PFPS a 99% incidence of pain in the lateral retinaculum, often at or near the retinaculopatellar junction, only 10% of knees demonstrated pain solely in the medial patellofemoral joint. This demonstrated the importance of periatellar retinaculum in PFPS.

In patients with PFPS both the step up and the step down may lack muscular control which may produce pain (Walsh, 1994:1171).

Shellock et al. (1989) using Magnetic Resonance Imaging on patients found patellar tracking

abnormalities in 83% of patients suffering from PFPS, while all of the asymptomatic subjects had normal patella tracking. The study subjects included 130 patients with clinical evidence of patella tracking abnormalities and 14 healthy subjects. Patella tracking abnormality may therefore be considered an important physical sign in PFPS.

Studies investigating the reflex response time of the quadriceps muscles have produced differing results. One study found that there were no differences between the symptomatic and asymptomatic groups with respect to the relative timing of initial vastus medialis oblique (VMO) and vastus lateralis (VL) activity (Karst and Willet, 1995). The other study found that in healthy individuals the VMO responds 1 to 3 seconds faster than VL. The reverse was true in PFPS indicating a reversal of the normal muscular firing order between the two muscles in these patients (Voight et al. 1991). Souza and Gross (1990) observed no differences in the VMO : VL electromyographic (EMG) ratios between healthy patients and those with PFPS.

Galanty et al. (1994) in a study involving 142 high school students found painful quadriceps setting to be the most specific physical examination finding (96% specificity), though its sensitivity was low (40%).

## 2.7 SYMPTOMS

Patients with PFPS present with retropatellar or peripatellar knee pain. The pain is usually dull and aching, becoming sharp with patella compressive activities. These include climbing or descending stairs, squatting or performing deep knee bends or sitting for prolonged periods

with the knees flexed (Davidson, 1993).

Thomee et al. (1995) found that other common symptoms other than pain were crepitus (85%) and giving way (58%). This was in a clinical analysis of common symptoms found in young women suffering from PFPS.

Galanty et al. (1994) found an affirmative response to either current knee pain, pain with stair climbing, or a theater sign yielded a sensitivity of 95% (62 of 65 subjects with clinical findings of anterior knee pain). The clinical findings of anterior knee pain were peripatellar pain, patella tendon pain and tuberosity pain.

## 2.8 DIAGNOSIS

The diagnosis of PFPS according criteria used by Powers, Landell and Perry (1996):

Localized pain originating from the peripatellar tissue or the patellofemoral joint and pain that was reproducible with a minimum of two of the following patella compressive tests:

- squatting
- kneeling
- prolonged sitting
- climbing stairs or
- isometric quadriceps contraction.

## 2.9 TREATMENTS

### 2.9.1 EXERCISE

Exercise therapy is commonly used in the conservative treatment protocol of PFPS and tends to focus on strengthening of the quadriceps femoris muscle group (Callaghan and Oldham, 1996).

Callaghan and Oldham (1996) believe that generalized quadriceps femoris exercises should be adapted and modified to be more specific in the light of previous and recent anatomical and physiological studies.

Stein et al. (1996) in a prospective, comparative clinical trial on 23 patients found closed kinetic chain training (squats and step ups) to be more effective in restoring patients perceived function with patellofemoral dysfunction than seated non weight bearing (open chain) joint isolation quadriceps exercises.

McConnel (1986) advocates modification of traditional training programs to facilitate contraction of VMO. Tria et al. (1992) believes that strengthening of the VMO should lead to improved tracking and less discomfort.

Stretching has been advocated to eliminate or decrease potential causes of compressive loads to the patella. Muscles stretched include gastrocnemius, hamstrings and quadriceps (Souza,

1990).

Biofeedback is the dynamic combination of learning processes and procedures in which the patient and therapist receive objective information about the immediate status of the physiological parameter (Sherman and Arena, 1993: 177). Reid believes that biofeedback may be used to augment training in patients with patellofemoral pain syndrome (1996: 387-389). Kellis and Baltzopoulos (1996) demonstrated that visual feedback improves gravity corrected eccentric moment output of knee flexors and extensors at both slow and fast angular velocities. The study showed that real time display of muscular moment output generated greater maximum moments of both knee muscle groups relative to the nonvisual feedback condition. They concluded that visual feedback appears to be a motivating factor for maximum muscular moment exerted during isokinetic eccentric activations. Kim and Kramer (1997) in agreement with the above study found enhanced knee extension torques with visual feedback. They state that visual feedback may be advantageous in learning a motor skill and strength training stimulus, especially during the initial phase of strength training. It must be noted that the above studies included only healthy subjects with no known knee pathology and the author feels that these results may not necessarily apply to patients with patellofemoral pain syndrome.

The emphasis on strengthening the VMO muscle seems to conflict with Shellock et al. (1989) who when using kinematic MRI to assess malalignments of the patella found medial subluxation of the patella in 41% of patients.

### 2.9.2 STRAPPING

Mc Connel (1986) in an uncontrolled study on 35 patients found that after 8 treatments 83% of her patients had no pain, 8.5% had reduced pain and 3% had no change in pain level. It must be noted that although the protocol was established the specific treatment for each patient was designed according to the examination findings, and included specific training of muscles which were thought to be contributing to patella malalignment. The mechanism of action was thought to be an alteration of the maltracking by the taping for which the quadriceps muscle later resumed responsibility. The tape was only applied after a thorough assessment of the orientation of the patella was made, and the patella was then taped to permit a more normal tracking. Taping was also thought to enhance contraction of the VMO. The author believes that the excellent results may have been contributed to by the exercise therapy. It must also be noted that this was an uncontrolled clinical observation and many questions remain as to how it achieved its success.

Herrigton and Payton (1997) conducted a non controlled study on 20 patients on the effect of taping of the patella on VMO and VL EMG activity and patients' perceived pain levels during maximal isometric quadriceps contraction. It was found that there were significant reductions in pain after application of tape at all joint angles tested, with no significant increase in VMO EMG activity. The mechanism by which the taping worked was said to be uncertain.

Bockrath et al. found patella taping to reduce perceived pain in patients by approximately 50% on a visual analogue scale during the 0.2m step down procedure. This trial was uncontrolled

and included 12 patients. It was postulated that the tape may provide neural inhibition via large afferent fibers, which override the pain signals.

In contrast to the above studies Kowell et al. (1996) in a prospective controlled study on 25 patients found no additional beneficial effect of adding a patellar taping program to standard physiotherapy. Patients in both groups found a marked reduction in pain, but there seemed to be no additional benefit in adding taping to the treatment programme.

There have been no satisfactory answers as to why patella taping causes a decrease in pain and no conclusive evidence that it realigns the patella or enhances VMO activity. The theories on neural mechanisms involving sensory input have been vague and difficult to measure (Callaghan, 1997).

### 2.9.3 BRACES

In an uncontrolled study by Villar (1985) it was found that only 22% of the 37 patients improved markedly with the use of an infrapatellar brace, with its success rate being too low for it to be regarded as a definitive treatment for PFPS. Patients were instructed to use the brace only when performing activities that would normally cause distress. All the patients said that the appliance was uncomfortable to wear in whatever position.

In a prospective controlled study carried out on 24 patients, Lysholm et al. (1984) found that the patella brace with a lateral pad supporting the patella improved quadriceps muscle peak strength. The results revealed that 88% of braced patients had an increase in their strength



performance test with 55% performing at 95% of their control leg strength. The best effects were seen in patients under the age of 30. It was thought that the brace prevented lateral slipping of the patella which according to Lysholm et al. supports the assumption that the major pathology in PFPS patients is lateral slipping of the patella.

#### 2.9.4 MEDICATION

Tria et al. (1992) states that drugs may be used as a sole therapeutic modality or in combination with other methods of treatment. He states that the use of steroids in the treatment of PFPS is not popular with the side effects and potential complications outweighing the potential benefits.

NSAID's may improve symptoms and expedite recovery period, however athletes with overuse syndromes will respond better to physiotherapy and activity modification (Tria et al. 1992). Enthusiasm for medical therapy (Non-steroidal anti-inflammatories) has waned (Reid, 1996:349). The side effects of this therapy include gastrointestinal disturbances, central nervous system effects, skin rashes, nephrotoxicity and bronchospasm, to name a few. Contra indications include among others asthma, porphyria, lactation, blood coagulation disorders, gastritis, peptic ulceration and hepatic dysfunction (Snyman and Pope, 1998:48-61).

#### 2.9.5 MODIFICATION OF ACTIVITY

Certain activities and positions of the knee are known to increase patellofemoral pain. Flexion

greater than 100 degrees, running and biking increase symptoms. Patients may initially be advised to avoid positions that provoke pain and to decrease activity exposure. Complete avoidance of specific sport activities is an extreme measure but may prevent surgical intervention (Tria et al. 1992).

## 2.9.6 SURGERY

The goal of patellofemoral surgery should be the maximum benefit with the least morbidity (Evans and Paulos, 1992).

Biedert, Stauffer and Friederich (1992) describe why surgery may fail. The retinaculum and the patella ligament show a high number of free nerve endings, indicating their importance in balancing the patella in the gliding mechanism. Incisions of the retinaculum will interrupt the connection between the patella and its guiding and controlling structures, this imbalance may lead to painful medial subluxations.

Kolwich et al. (1990) reviewed 202 patients who had had a lateral release of the patella, of these 100 patients were classified as having good or excellent results (group I) and 43 patients were identified as having a failed lateral release which was defined as requiring further surgery (group II). Seventy six percent of the patients in the successful group, group I, had a preoperative diagnosis of lateral compression syndrome with only 24% of the patients having patella instability. Comparing the preoperative passive patella tilt to successful results, 77% were negative, 15% were positive and 8% had unavailable values. Sixty three percent of

patients displayed a medial patella glide of two quadrants or less preoperatively. The tubercle sulcus angle was abnormally increased in only 10% of these knees. In group II, 55% of the patients had a lateral release for patella dislocation. Only 45% had a preoperative diagnosis of lateral patella compression syndrome. Sixteen patients in group II required a vastus lateralis repair for overrelease of lateral structures, of these 5 patients had a positive patella tilt test preoperatively and the remainder of the patients had no recorded results. Nineteen patients in group II underwent a proximal distal patella reconstruction, 15 of these patients had a preoperative tubercle sulcus angle greater than or equal to 10 degrees. Proximal realignment was necessary in 8 knees, 5 of the 8 knees had a known preoperative lateral patella glide of more than two quadrants. It was concluded that a positive patella tilt test, a hypermobile patella and an abnormal tubercle-sulcus angle are poor prognostic indicators for a solitary lateral release.

In an 11 year follow up of 48 patients, Karlsson et al. (1996) evaluated the long term results in patients with PFPS after non surgical conservative management, 85% of the patients rated their knee function as excellent or good and did not require further treatment. It was concluded that PFPS should be managed nonsurgically as in most cases the natural course is benign.

Pinshaw and Noakes (1984) reported that 86% of 196 runners with PFPS were completely cured when they followed all the advice given to them. Advice was given on running shoes, in shoe supports, correction for leg length discrepancies, training methods, ice application and referral for physiotherapy. This suggests that good results may be achieved with conservative

care without recourse to empirical treatment.

## **2.9.7 MOBILIZATION**

BenEliyahu (1992), Dryburgh (1988), Chadwick (1987), Fulkerson and Shea (1990), Linsheng (1991) and Turchin and Mootz (1995) have described mobilization of the patellofemoral joint as part of a conservative treatment protocol.

Many forms of patella and knee manipulative techniques have been described as part of a therapeutic protocol for PFPS, according to Souza (1990) these techniques all strive to restore accessory motion to the knee joint and disrupt scar formation.

Rowlands (1999) in a placebo controlled study on mobilization of the patella found that the intragroup comparison showed the treatment group to have a greater response than the placebo group. The intergroup comparison revealed a statistically significant difference in objective findings (P-value 0.0086 and 0.0061). Improvement in intergroup subjective data was not found to be statistically significant. The study was relatively small with 15 subjects in each group.

## **2.10 ACTION POTENTIAL THERAPY (APT)**

### **2.10.1 INTRODUCTION**

Action Potential Therapy was developed in South Africa in 1992 and has been used as a stand

alone treatment by both the layman and by health professionals since 1994. (Berger, 1999: 11).

Action Potential Therapy is a low frequency current that mimics the naturally occurring action potential found in a neuron. The current mimics the body's natural electrical impulse, which then causes cycle synchronous depolarization (Berger and Matzer, 1999).

### 2.10.2 ACTION POTENTIAL

Nerve signals are transmitted by action potentials (Guyton, 1992: 47). To conduct a nerve signal, the action potential which is a propagation of the nerve impulse travels along the nerve fiber until it comes to the fibers' end. The action potential is divided into 3 successive stages namely:

**Resting stage:** This is the resting membrane potential. The membrane is polarized, that is there is a very large negative membrane potential. This is the stage before the action potential occurs.

**Depolarization stage:** The membrane of the nerve fiber contains voltage activated ion channels. These channels are sensitive to voltage across the membrane and when the voltage reaches a critical point, the gates open allowing the passage of specific ions through the channels. At this stage the membrane becomes permeable to sodium ions which flow through the channels into the axon. The nerve fiber depolarizes moving away from its depolarized state of -90mV, with the potential approaching the zero level. In large fibers the membrane potential may "overshoot" beyond the zero level, with a momentary reversal in polarity.

**Repolarization stage:** After a few 10,000ths of a second after becoming permeable to sodium

ions, the sodium channels begin to close with the potassium channels opening. The diffusion of potassium ions externally re establishes the normal negative resting potential of the nerve fiber. That is the nerve is repolarized (Guyton, 1992:47).

### **2.10.3 ACTION POTENTIAL CURRENT THERAPY**

APT is said to simulate or mimic the action potential that occurs naturally in a neuron (Berger, 1999: 28).

Injury or disease processes can result in poor transmission or even cessation of activity along the neuron. If the action potential mechanism can be restored to normal, injury and disease can be affected at a cellular level and health of the organism improved or regained. This is the alleged action of APT (Berger, 1999: 31).

The current created by "Action Potential" therapy modality is stronger than the normal current required to produce the action potential in the neuron and as a result depolarization takes place (Berger, 1999: 31). Stimulation by the APT current creates a normal action potential which restores the inherent biochemical processes in the region (Berger and Matzner, 1999).

APT current is neither direct, interrupted direct, alternating, nor rectified alternating. It is a combination of direct and alternating current that cannot be compared to any other waveform at present. The current created is a mono-phasic square pulse with exponential decay (Berger,

1999:32).

Berger (1999: 33-34) lists the following possible physiological effects of APT:

1. Electrolytic effects in the treated area, it is postulated that there is a break down of biochemical waste from uric acid, inflammation and excess fluid.
2. Leu-enkephalin, a pain modulating hormone, levels are increased.
3. Melatonin levels are increased. Melatonin is an anti-anxiolytic that induces relief from anxiety and has beneficial effects on muscle spasm.
4. Circulation improves resulting in increased transportation of antibodies, enzymes, neurotransmitters and hormones toward the area.
5. Improved circulation may positively effect lymph drainage in the area or the limb.

De Wet and Oosthuizen (1999) in their study on the neurohormonal consequences of APT report the possibility of the following beneficial effects:

1. Analgesia due to more effective utilization of the endogenous opioids and the inhibition of pain transmission.
2. Reduced anxiety and a more realistic self assessment of pain.
3. Limitation of tissue damage at sites of inflammation and or hypoxia due to local vasodilation and better perfusion of the affected areas.
4. Anti inflammatory effects due to beneficial influences on the prostaglandin mechanisms.

#### **2.10.4 A COMPARISON OF ACTION POTENTIAL THERAPY TO TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION THERAPY**

The effect of transcutaneous electrical nerve stimulation (TENS) is obtained by stimulation of large low threshold sensory nerve fibers (Berger, 1999: 17). According to the gate control theory by Melzack and Wall (1988: 98), this would inhibit cells which transmit injury signals. The pulses produced by TENS are balanced biphasic pulses, whereas the APT unit produces a current that is monophasic, with an exponential decay, with a negative balance produced between the polarities, therefore, facilitating depolarization of the nerve. This is the major difference between TENS and APT (Berger, 1999: 17,20). Stimulation by the APT current creates a normal action potential which restores the inherent biochemical processes in the region (Berger and Matzner, 1999), whereas TENS produces pain suppression by means of the gate control theory (Berger, 1999: 17).

#### **2.10.5 CLINICAL TRIALS ON ACTION POTENTIAL THERAPY**

The original prototype of the Action Potential Current Therapy unit was tested at various universities in South Africa with promising results.

A "patient blinded", placebo controlled, randomized, prospective study entitled: "An Investigation into the Neurohormonal Consequences of Action Potential Stimulation Therapy" (De Wet and Oosthuizen, 1999) was executed on 20 patients in the Pain Control Unit,



National Hospital, University of the Orange Free State, Bloemfontein, in 1997. The study was aimed at evaluating the neurohormonal effects of APT in patients with chronic back pain due to osteoporosis. Blood samples were taken and radio-immune essays used to determine hormone concentrations after APT. The results demonstrated an increase in the serum concentration of melatonin(endogenous anxiolytic) after the second treatment and in leu-enkephalin(endogenous peripheral analgesic) after the fourth treatment. Beta-endorphin(endogenous central analgesic) concentrations decreased after five treatments and serotonin(endogenous anti-depressant) and cortisol(endogenous anti-inflammatory) levels remained within normal limits after six treatments.

A randomized, patient blinded, placebo controlled study involving 76 patients with chronic backache owing to osteoporosis was conducted at the Pain Control Unit, Department of Anaesthesiology, University of the Orange Free State, Bloemfontein by Oodendaal et al. (1999). Patients received 6 treatments consisting of 32 minutes (16 minutes followed by a 3 minute interval followed by a further 16 minutes) every second day. The results showed a statistically significant improvement from the baseline to all subsequent time points except for APT group visit 1 and Placebo group visits 1,4 and 6. Clinically the effect of treatment was concluded to be successful.

A randomized, single blinded, placebo controlled study involving 99 patients with osteoarthritis of the knee was conducted at the Pain Relief and Research Unit, Department of Anaesthesiology, Baragwanath Chris Hani Hospital, University of Witwatersrand. APT was

found to improve mobility, decrease night pain and reduce the use of analgesics in patients (Berger, 1999). It was concluded that APT was statistically proven to be effective in the treatment of patients with osteoarthritis of the knee.

### **2.10.6 CONTRAINDICATIONS TO ACTION POTENTIAL THERAPY**

According to manufacturers' guidelines APT should not be used :

- By patients with any electrical medical implants.
- By patients predisposed to thrombolytic episodes.
- By patients with epilepsy.
- Over the abdominal area of pregnant women.
- In the vicinity of a malignant tumor.
- Directly over the eye.
- In children under the age of 12 and persons with a body mass of less than 15 kilograms.

APT may however be used by patients with metal prosthesis or Harrington rods.

### **2.10.7 TECHNICAL SPECIFICATIONS OF THE ACTION POTENTIAL RECTIFICATION THERAPY DEVICE (Medi Pulse Pty**

Ltd, Private Bag X1116, Halfway House, 1685, South Africa)

- Wave form name      Action Potential Current

- Wave type                      Positive pulse with exponential decay
- Pulse rate                     166Hz
- Amplitude                    Adjustable between 0 to 5 mA peak in 1000 ohm load
- Voltage                        0-48 volts (open circuit)

## **CHAPTER 3: METHODOLOGY**

### **3.1 OBJECTIVES OF THE STUDY**

The objective of this study was to evaluate the relative effectiveness of combined patella mobilization and “Action Potential Therapy” versus combined patella mobilization and placebo “Action Potential Therapy”, in terms of objective and subjective findings, in the treatment of Patellofemoral Pain Syndrome.

**3.1.1** The first objective was to determine the relative effectiveness of patella mobilization and “Action Potential Therapy” versus patella mobilization and placebo “Action Potential Therapy” in the treatment of Patellofemoral Pain Syndrome, in terms of objective measures.

**3.1.2** The second objective was to determine the relative effectiveness of patella mobilization and “Action Potential Therapy” versus patella mobilization and placebo “Action Potential Therapy” in the treatment of Patellofemoral Pain Syndrome, in terms of subjective measures.

### **3.2 STUDY DESIGN AND PROTOCOL**

The design was that of a prospective, single blinded, randomized, placebo controlled study.

Subjects were informed of the study via local notice boards and newspapers. The study incorporated 60 patients who were accepted according to an inclusion criteria. Patients were randomly assigned to either the treatment group, Group A or the control group, Group B. Each group consisted of 30 patients.

Each patient was treated on 4 occasions, the first treatment consisted of patella mobilization and APT (group one) or patella mobilization and placebo APT (group two), treatment 2,3 and 4 consisted of APT (group one) or placebo APT (group two).

### **3.2.1 STANDARD OF ACCEPTANCE**

At the initial consultation the candidate underwent a full case history (Appendix A) and knee regional examination (Appendix B). During this process the patient was screened for Patellofemoral Pain Syndrome. Acceptance of the candidate was dependent on whether or not they met the specific inclusion criteria.

### **3.2.2 INCLUSION CRITERIA**

Patients had to be between the age of 18 to 65 years to be included into the study.

The inclusion criteria was based on that used by Powers, Landel and Perry (1996).

Diagnosis of PFPS was confirmed by:

- 1) localized pain originating from the peri-patella tissue of the patellofemoral joint and
- 2) pain that was reproducible on a minimum of two of the following
  - squatting,
  - kneeling,
  - prolonged sitting,
  - climbing steps, or

- isometric quadriceps femoris muscle contraction.

Patients were excluded for the following reasons:

- bursitis
- patella tendinitis
- fat pad syndrome
- ligament instability
- major internal derangement
- plica syndrome
- systemic arthritides affecting the knee
- a recent history of patella dislocation
- knee surgery within the past two years
- neurological involvement affecting gait.

The APT manufacturers' (Medi Pulse Pty Ltd, Private Bag X1116, Halfway House, 1685, South Africa) guidelines further precluded usage in the following situations:

- pregnancy
- patients with epilepsy
- patients predisposed to thrombolytic episodes
- patients with any electrical implant.

Patients were further excluded if they were using anti-inflammatory or analgesic medication as this might have altered the findings.

X- Rays were taken if clinically indicated to rule out any contra indications to patients being included in the study. X- Rays were bilateral with anterior, lateral and sunrise views.

### 3.2.3 INTERVENTION

Subjects found suitable for the study were given a letter of information and were asked to complete an informed consent form(Appendix C ).

Patients were randomly assigned to one of the two groups each consisting of 30 patients.

A “double blind” procedure was used to ensure the placebo nature of the study. The manufacturer made available four units for the study. The units were marked as “a,b,c or d”. The patient was assigned to a unit by drawing a letter (a,b,c or d) out of a cup, there were 15 pieces of paper with each letter. Each patient was treated with the same unit for the duration of the study. After the data was collected and analyzed, the true nature of the units was revealed and the results reported on. The result was two equal groups, one receiving active Action Potential Therapy and the other receiving placebo Action Potential Therapy. The researcher was however partially unblinded by the patient response to treatment, this is discussed in chapter 6 under recommendations.

Both groups were informed as to how Action Potential Therapy might be effective in treating their condition.

Patients were required to attend the clinic 5 times over a period of approximately 2 weeks.

Patients received a maximum of one treatment per day. Patients were treated on visit 1,2,3 and 4 with data being collected on visits 1,2 and 5. Treatment one consisted of patella mobilization and Action Potential Therapy (active or placebo). Treatment 2,3 and 4 consisted of active or placebo Action Potential Therapy.

Mobilization of the patella was done in all directions while the patient was supine with gentle pressure exerted against resistance (Turchin and Mootz, 1995).

Action Potential treatments were standardized at 8 minutes duration. The intensity that depended on individual response but was not set above 2mA. Electrodes were placed medial and lateral to the patella.

Patients were advised against any major lifestyle changes such as diet and exercise. Patients were further asked to abstain from the usage of anti-inflammatory or analgesic medication.

### **3.2.4 ETHICAL CONSIDERATIONS**

The rights and welfare of the patients were protected:

- informed consent was made
- the patient was not be coerced into participating in the study
- information was given to the patient in an understandable language
- the research involved no more than minimal risk



- confidentiality was maintained
- participation was voluntary and did not involve financial benefits
- patients were free to withdraw from the study at any stage (Pak and Adams, 1994: 37).

### **3.3 MEASUREMENT AND OBSERVATION**

#### **3.3.1 THE DATA**

The study incorporated both primary and secondary data as mentioned below:

##### **3.3.1 PRIMARY DATA**

- Case history (Appendix A)
- Knee regional examination (Appendix B)
- Patient- Specific Functional Scale (Appendix D)
- Numerical Pain Rating Scale 101 (Appendix E)
- Short-form Mc Gill Pain Questionnaire (Appendix F)
- Algometer reading for Pressure-pain Threshold

##### **3.3.1.2 SECONDARY DATA**

Literature was obtained from journals, text books and the internet.

#### **3.3.2 METHOD OF MEASUREMENT**

##### **3.3.2.1 SUBJECTIVE MEASUREMENT**

###### **1) THE PATIENT SPECIFIC FUNCTIONAL SCALE**

This scale was developed to assess disability and change in disability. Chatman et al. (1997)

studied the reliability, validity and sensitivity to change over time of the scale and found it to be a time efficient and appropriate tool when the goal is the assessment of change in disability. Patients were asked to list up to five specific activities that they were having difficulty with. They were then asked to rate the difficulty associated with each activity using an 11 point scale, where 0 meant that they were unable to perform the activity and 10 meant that they could perform the activity as well as normal. Upon completion of the questionnaire the points were added and “averaged” by dividing the total number of points obtained by the number of responses made.

## 2) THE NUMERICAL PAIN RATING SCALE -101

The NRS - 101 consists of asking the patient to rate their perceived level of pain intensity on a numerical scale from 0 to 100, with the 0 representing “no pain” and the 100 representing “pain as bad as it could be”. This scale was found to be the most practical index when measuring clinical pain intensity as compared to 5 other scales. It’s advantages were

- it is simple to administer and score
- oral and written responses may be used
- age doesn’t affect the scale (Jensen, Karoly and Braver, 1986).

Upon completion of the questionnaire values recorded for pain at its worst and pain at its least were added to form a final score.

## 3) THE SHORT FORM MCGILL PAIN QUESTIONNAIRE

The short form McGill Pain Questionnaire provides valuable information on the patients

sensory, affective and evaluative dimensions of pain experience in a limited time frame. It was derived from the standard McGill Pain Questionnaire for more rapid acquisition of data. The questionnaire consists of 15 representative words (descriptors) which are rated on an intensity scale as 0 = none, 1 = mild, 2 = moderate or 3 = severe (Melzack, 1987). On completion of the questionnaire the points were added to form a final score for that consultation.

### 3.3.2.2 OBJECTIVE MEASURES

Algometer readings were taken to measure changes in pressure-pain threshold. This measurement has been found adequate for quantification of tender spots in soft tissues. It has been found to be particularly useful in assessing treatment results (Fischer, 1987). Nussum and Downes (1998) report reliability of clinical pressure pain algometric measurements.

The algometer used was the force dial manufactured by Wagner Instruments: PO Box 1217, Greenwich CT 06836. The pressure range of the algometer was 11 kg.

The area of tenderness was located through palpation of the peripatellar area. The footplate was placed over the area of tenderness with the shaft exerting pressure in the direction of the pain produced on palpation. The gauge was turned away from the patient and the pressure was increased at a rate of approximately 1kg/ cm squared / second. The patients were informed to indicate when they first sensed the pain produced by the pressure by saying "yes".

Upon the patients' response the instrument was removed and the measurement recorded in kg per square centimeter.

### 3.4 THE LOCATION OF DATA

The primary data was obtained from the Mc Gill Pain Questionnaire, the NRS-101, the PSFS and the algometer readings. Data was collected at the first visit pre-treatment one, on the second visit pre-treatment two, and at the follow up consultation. All consultations took place at the Technikon Natal Chiropractic Day Clinic.

The secondary data was obtained from journals and text books.

### 3.5 STATISTICAL ANALYSIS

The SPSS statistical package (as supplied by SpSS Inc., Marketing Department, 444 North Michigan Avenue, Chicago, Illinois, 60611) was utilized for data analysis. The statistical evaluation was aimed at measuring whether any significant changes occurred between the initial and second consultation, the initial and fifth consultation, as well as the second and fifth consultation, within each study group as well as any significant differences at the time of the initial, second and fifth consultation between the different study groups.

The **Mann-Whitney Test** (non-parametric test) was used to determine whether any significant differences occurred between the two groups at the time of the initial, second and fifth

consultation for categorical variables. The categorical variables included the McGill Short Form Pain Questionnaire.

The **two-sample unpaired t-test** (parametric test) was used to determine whether any significant differences occurred between the two groups at the time of the initial, second and fifth consultation for continuous variables. The continuous variables were the NRS-101, the PSFS and the algometer.

The **Wilcoxin Signed Rank Test** (non-parametric test) was used to determine whether any significant change occurred between:

- the initial and second consultation,
- the second and fifth consultation and
- the initial and fifth consultation, within each study group for the categorical variables. The categorical variables included the McGill Short Form Pain Questionnaire.

The **two-sampled paired t-test** (parametric test) was used to determine whether any significant change occurred between:

- the initial and second consultation,
- the second and fifth consultation and
- the initial and fifth consultation, within each study group for the continuous variables. The continuous variables were the NRS-101, PSFS and the algometer.

Descriptive statistics were used, incorporating mean, standard deviation and standard error to analyze the **P values** (level of statistical significance) acquired in order to further interpret the results from data collected once in a spread sheet format. The P value is defined as the probability of obtaining an outcome as or more extreme than that observed in the study if the null hypothesis were true, if the P value is low we might decide to reject the null hypothesis as incorrect (Coggon, 1995: 66).

Measurement of the central tendency found within the raw data was interpreted by calculating **the mean value (Me.)**. This provided a practical quantitative summary of each groups' characteristics. The mean value was calculated by summing the values of several observations and dividing by the number of observations (Portney, 1993: 321-322).

From the mean values the **standard deviation (S.D.)** was calculated to measure the variation of the data from the mean values acquired (Portney, 1993: 692).

**Standard error (S.E.) of measurement** is a reliability measurement of response stability, estimating the standard error in a set of repeated scores. A test administered to one individual an infinite number of times would lead to a varied response. These differences would be a function of random measurement error. If a graph was drawn to plot these responses, the distribution would presents a normal curve, with the mean equal to the true score and errors falling above and below the mean. The distribution of measurement errors is a theoretical

distribution that represents the population of all possible measurement errors that could occur for that variable. With a more reliable measurement, errors would be smaller and the distribution would be less variable. The standard deviation of the measurement errors reflects the reliability of the response. The standard deviation is the standard error of measurement (Portney 1993: 523-524).

The **power** analysis was computed for the intra-group continuous variables using the following UCLA web site: <http://www.stat.ucla.edu/calculators/powercalc/normal>. The value was then converted into a percentage. The closer the power value to 100% the smaller the probability of accepting a type two error and the greater the sensitivity of the test.

The results of these tests were then used to discuss and draw conclusions as to the relative effectiveness of combined patella mobilization and APT versus combined patella mobilization and placebo APT in the treatment of Patellofemoral Pain Syndrome.

## CHAPTER 4: THE RESULTS

### 4.1 INTRODUCTION

This chapter deals with the results accompanied by relevant interpretations obtained after statistically analyzing the data from the measurement criteria utilized namely:

- the Numerical Pain Rating Scale-101
- the Patient Specific Functional Scale
- the short form McGill Pain Questionnaire
- the algometer readings.

The age and gender distribution are tabulated.

The results obtained for the inter and intra group data analysis are tabulated. The tables for statistical results include the mean (Me.), standard deviation (Sd.), standard error (Se.) and the level of significance (P-value). Findings for subjective and objective findings are tabulated separately.

The power analysis was only computed for the intra-group continuous variables namely the algometer readings and the NRS-101 scores and are tabulated below the appropriate tables. Results of the Power test determine whether a type II error may have occurred, which will occur 5% of the time at a 95% confidence level. Any result of 50% or greater is acceptable, it must be noted that the gold standard for the Power test is usually 80% but with small sample



sizes power will typically be poor.

The mean value of each variable is represented graphically for both groups.

## 4.2 CRITERIA GOVERNING THE ADMISSIBILITY OF DATA

Data collected from patients who met with the criteria of the study was used. Only responses to the NRS-101, McGill and PSFS, completed under the researchers' supervision were utilized. Similarly, only the algometric measurements for pressure pain threshold taken by the researcher were used.

## 4.3 THE HYPOTHESIS

The null hypothesis ( $H_0$ ) was the same for group one and two, it is stated below:

**$H_0$ :** On analysis of the intra-group data there would be no statistical improvement in the subjective and objective findings, indicating that the treatment was statistically insignificant.

The alternative hypothesis ( $H_a$ ) is the same for both groups and is described below:

**$H_a$ :** On analysis of the intra-group data there would be a statistical improvement in the subjective and objective findings, indicating that the treatment was statistically significant.

Integrating the data from the two groups required a further null hypothesis and an alternative hypothesis described below:

**H<sub>0</sub>:** On analysis of the inter-group data there would be no statistical difference in the objective and subjective findings indicating that the two treatments were equally effective.

**H<sub>a</sub>:** On analysis of the inter-group data there would be a statistical difference in the objective and subjective findings indicating that the two treatments were not equally effective.

## 4.4 THE ANALYZED DATA

### 4.4.1 P-VALUE

The data was analysed at the  $\alpha = 0.05$  level and the decision rule was applied as follows:

Reject the null hypothesis if the P-value is  $\leq \alpha / 2$ .

Accept the null hypothesis if the P-value is  $\geq \alpha / 2$ , where  $\alpha / 2 = 0.025$ .

Therefore to conclude that there is a statistically significant improvement at the  $\alpha = 0.05$  level, the P-value would have to be  $\leq 0.025$ .

### 4.4.2 THE POWER VALUE

The power value is used to determine the sensitivity of the statistical tests by assessing the probability of a particular test to detect a difference between the groups. The power values were calculated and then converted into percentages. The closer the power value to 100% the smaller the probability of accepting a type II error and the greater the sensitivity of the tests.

## 4.5 TABLES OF DEMOGRAPHIC DATA

TABLE 4.1 Age distribution

AGE	TREATMENT GROUP	CONTROL GROUP	TOTAL % OF PATIENTS
18-24	8	8	27
25-34	7	8	25
35-44	7	7	23
45-54	5	6	18
55-65	3	1	7

TABLE 4.2 Gender distribution

GENDER	TREATMENT GROUP	CONTROL GROUP	TOTAL
Male	18	13	31
Female	12	17	29

4.6 TABLES OF STATISTICAL RESULTS

Significant P-Values are highlighted.

4.6.1 STATISTICAL RESULTS COMPARING THE SUBJECTIVE MEASURES OF THE TREATMENT GROUP

TABLE 4.3 Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient specific functional scale comparing the first and second visits of the treatment group.

	TREATMENT GROUP VISIT 1			P-VALUE	TREATMENT GROUP VISIT 2		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	83.6	26	4.75	.703	81.93	37.85	6.91
McGILL	12	5.92	1.08	.001	8.5	6.52	1.19
PSFS	3.92	1.62	0.3	.001	4.89	2.08	0.38

The Wilcoxon’s signed rank test was used to compare results within each group for the categorical variables, ie: McGill.  
The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: NRS-101 and PSFS.

The null hypothesis was rejected for the McGill and PSFS questionnaires, indicating a significant improvement between the first and second visits in the treatment group.  
However the null hypothesis was accepted for the NRS-101 questionnaire, indicating no significant improvement over the same treatment interval.

**TABLE 4.4** Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient specific functional scale comparing the first and fifth visits of the treatment group.

	TREATMENT GROUP VISIT 1			P-VALUE	TREATMENT GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	83.6	26.01	4.75	.000	60.37	37.61	6.87
McGILL	12	5.92	1.08	.000	5.03	5.67	1.04
PSFS	3.92	1.62	0.3	.000	7.51	3.06	0.56

The Wilcoxon’s signed rank test was used to compare results within each group for the categorical variables, ie: McGill.  
The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: NRS-101 and PSFS.

The null hypothesis was rejected for the NRS-101, McGill and PSFS questionnaires, indicating a significant improvement between the first and fifth visits in the treatment group.

**TABLE 4.5** Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient specific functional scale comparing the second and fifth visits of the treatment group.

	TREATMENT GROUP VISIT 2			P-VALUE	TREATMENT GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	81.93	37.85	6.91	.000	60	37.61	6.87
McGILL	8.5	6.52	1.19	.000	3	5.67	1.04
PSFS	4.89	2.08	0.38	.000	7.67	3.06	0.56

The Wilcoxon's signed rank test was used to compare results within each group for the categorical variables, ie: McGill.  
The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: NRS-101 and PSFS.

The null hypothesis was rejected for the NRS-101, McGill and PSFS questionnaires, indicating a significant improvement between the second and fifth visits in the treatment group.

4.6.2 STATISTICAL RESULTS COMPARING THE SUBJECTIVE MEASURES OF THE CONTROL GROUP

TABLE 4.6 Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient specific functional scale comparing the first and second visits of the control group.

	CONTROL GROUP VISIT 1			P-VALUE	CONTROL GROUP VISIT 2		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	81.7	29.1	5.31	.014	76.9	28.22	5.15
McGILL	10.2	5.88	1.07	.045	8.67	5.74	1.05
PSFS	4.33	1.72	0.31	.006	4.71	1.91	0.35

The Wilcoxon’s signed rank test was used to compare results within each group for the categorical variables, ie: McGill.  
The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: NRS-101 and PSFS.

The null hypothesis was rejected for the NRS-101 and PSFS questionnaires, indicating a significant improvement between the first and second visits in the control group.  
However the null hypothesis was accepted for the McGill questionnaire, indicating no significant improvement over the same treatment interval.

**TABLE 4.7** Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient specific functional scale comparing the first and fifth visits of the control group.

	CONTROL GROUP VISIT 1			P-VALUE	CONTROL GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	81.73	29.1	5.31	.001	59.83	41.02	7.49
McGILL	10.2	5.88	1.07	.000	5.03	4.11	0.75
PSFS	4.33	1.72	0.31	.000	6.55	2.13	0.39

The Wilcoxon’s signed rank test was used to compare results within each group for the categorical variables, ie: McGill.  
The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: NRS-101 and PSFS.

The null hypothesis was rejected for the NRS-101, McGill and PSFS questionnaires, indicating a significant improvement between the first and fifth visits of the control group.



**TABLE 4.8** Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient specific functional scale comparing the second and fifth visits of the control group.

	CONTROL GROUP VISIT 2			P-VALUE	CONTROL GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	76.9	28.22	5.15	.003	59.83	41.02	7.49
McGILL	8.67	5.74	1.05	.000	5.03	4.11	0.75
PSFS	4.71	1.91	0.35	.000	6.55	2.13	0.39

The Wilcoxon’s signed rank test was used to compare results within each group for the categorical variables, ie: McGill.  
The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: NRS-101 and PSFS.

The null hypothesis was rejected for the NRS-101, McGill and PSFS questionnaires, indicating a significant improvement between the second and fifth visits of the control group.

4.6.3 STATISTICAL RESULTS COMPARING THE OBJECTIVE MEASURES IN THE TREATMENT GROUP

TABLE 4.9 Statistical results of the algometric measurements comparing the first and second visits of the treatment group.

	TREATMENT GROUP VISIT 1			P-VALUE	TREATMENT GROUP VISIT 2		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	3.57	1.77	0.32	.000	4.57	2.03	2.03

The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: Algometer.

The null hypothesis was rejected for the algometric measurements, indicating a significant improvement between the first and second visits in the treatment group.

**TABLE 4.10** Statistical results of the algometric measurements comparing the first and fifth visits of the treatment group.

	TREATMENT GROUP VISIT 1			P-VALUE	TREATMENT GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	3.57	1.77	0.32	.000	5.09	2.24	0.41

The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: Algometer.

The null hypothesis was rejected for the algometric measurements, indicating a significant improvement between the first and fifth visits in the treatment group.

**TABLE 4.11** Statistical results of the algometric measurements comparing the second and fifth visits of the treatment group.

	TREATMENT GROUP VISIT 2			P-VALUE	TREATMENT GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	4.57	2.03	2.03	.000	5.09	2.24	0.41

The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: Algometer.

The null hypothesis was rejected for the algometric measurements, indicating a significant improvement between the second and fifth visits in the treatment group.

4.6.4 STATISTICAL RESULTS COMPARING THE OBJECTIVE MEASURES IN THE CONTROL GROUP

TABLE 4.12 Statistical results of the algometric measurements comparing the first and second visits of the control group.

	CONTROL GROUP VISIT 1			P-VALUE	CONTROL GROUP VISIT 2		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	3.4	1.37	0.25	.002	3.58	1.37	0.25

The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: Algometer.

The null hypothesis was rejected for the algometric measurements, indicating a significant improvement between the first and second visits in the control group.

**TABLE 4.13** Statistical results of the algometric measurements comparing the first and fifth visits of the control group.

	CONTROL GROUP VISIT 1			P-VALUE	CONTROL GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	3.4	1.37	0.25	.024	3.62	1.34	0.24

The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: Algometer.

The null hypothesis was rejected for the algometric measurements, indicating a significant improvement between the first and fifth visits.

**TABLE 4.14** Statistical results of the algometric measurements comparing the second and fifth visits of the control group.

	CONTROL GROUP VISIT 2			P-VALUE	CONTROL GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	3.58	1.37	0.25	.557	3.62	1.34	0.24

The two-sample paired t-test was used to compare results within each group for the continuous variables, ie: Algometer.

The null hypothesis was accepted for the algometric measurements, indicating no significant improvement between the second and fifth visits in the control group.

4.6.5 STATISTICAL RESULTS COMPARING THE SUBJECTIVE MEASURES FOR THE FIRST VISIT FOR THE TREATMENT AND CONTROL GROUPS

TABLE 4.15 Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient Specific Functional Scale comparing the first visit for the treatment and control groups.

	TREATMENT GROUP VISIT 1			P-VAL	CONTROL GROUP VISIT 1		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	83.6	26.01	4.75	.794	81.73	29.1	5.31
McGILL	12	5.92	1.08	.210	10.2	5.88	1.07
PSFS	3.92	1.62	0.3	.353	4.33	1.72	0.31

The Mann-Whitney unpaired U test was used to compare the two groups with respect to each categorical variable, ie: McGill.  
The two-sample unpaired t-test was used to compare the two groups with respect to each continuous variable ie: NRS-101 and PSFS.

POWER

NRS-101	16.62%
PSFS	95.02%

The null hypothesis was accepted for the NRS-101, McGill and PSFS questionnaires, indicating no significant difference between the treatment and control group, at the first visit.



4.6.6 STATISTICAL RESULTS COMPARING THE SUBJECTIVE MEASURES FOR THE SECOND VISIT FOR THE TREATMENT AND CONTROL GROUPS

TABLE 4.16 Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient Specific Functional Scale comparing the second visit for the treatment and control groups.

	TREATMENT GROUP VISIT 2			P-VALUE	CONTROL GROUP VISIT 2		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	81.93	37.85	6.91	.562	76.9	28.22	5.15
McGILL	8.5	6.52	1.19	.689	8.67	5.74	1.05
PSFS	4.89	2.08	0.38	.731	4.71	1.91	0.35

The Mann-Whitney unpaired U test was used to compare the two groups with respect to each categorical variable, ie: McGill.  
The two-sample unpaired t-test was used to compare the two groups with respect to each continuous variable ie: NRS-101 and PSFS.

POWER

NRS-101	59.63%
PSFS	25.96%

The null hypothesis was accepted for the NRS-101, McGill and PSFS questionnaires, indicating no significant difference between the treatment and control group, at the second visit. There was a possibility of accepting a type II error for PSFS due to the low power.

4.6.7 STATISTICAL RESULTS COMPARING THE SUBJECTIVE MEASURES FOR THE FIFTH VISIT FOR THE TREATMENT AND CONTROL GROUPS

TABLE 4.17 Statistical results of the Numerical Rating Scale-101, short-form McGill Pain Questionnaire and Patient Specific Functional Scale comparing the fifth visit for the treatment and control groups.

	TREATMENT GROUP VISIT 5			P-VALUE	CONTROL GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
NRS-101	60.37	37.61	6.87	.958	59.83	41.02	7.49
McGILL	5.03	5.67	1.04	.518	5.03	4.11	0.75
PSFS	7.51	3.06	0.56	.167	6.55	2.13	0.39

The Mann-Whitney unpaired U test was used to compare the two groups with respect to each categorical variable, ie: McGill.  
The two-sample unpaired t-test was used to compare the two groups with respect to each continuous variable ie: NRS-101 and PSFS.

POWER

NRS-101	51.04%
PSFS	100%

The null hypothesis was accepted for the NRS-101, McGill and PSFS questionnaires, indicating no significant difference between the treatment and control group, at the fifth visit.

4.6.8 STATISTICAL RESULTS COMPARING THE OBJECTIVE MEASURES FOR THE FIRST VISIT FOR THE TREATMENT AND CONTROL GROUPS

TABLE 4.18 Statistical results of the algometric measurements comparing the first visit of the treatment and control group.

	TREATMENT GROUP VISIT 1			P -VALUE	CONTROL GROUP VISIT 1		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	3.57	1.77	0.32	.668	3.4	1.37	0.25

The two-sample unpaired t-test was used to compare the two groups with respect to each continuous variable ie: Algometer.

POWER

ALGOMETER	34.86%
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The null hypothesis was accepted for the algometric measurements, indicating no significant difference between the treatment and control groups, at the first visit.

There was a greater chance of accepting a type II error as the power analysis was less than 50%.

4.6.9 STATISTICAL RESULTS COMPARING THE OBJECTIVE MEASURES FOR THE SECOND VISIT FOR THE TREATMENT AND CONTROL GROUPS

TABLE 4.19 Statistical results of the algometric measurements comparing the second visit of the treatment and control group.

	TREATMENT GROUP VISIT 2			P -VALUE	CONTROL GROUP VISIT 2		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	4.57	2.03	2.03	.031	3.58	1.37	0.25

The two-sample unpaired t-test was used to compare the two groups with respect to each continuous variable ie: Algometer.

POWER

ALGOMETER	100%
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The null hypothesis was accepted for the algometric measurements, indicating no significant difference between the treatment and control groups, at the second visit.

4.6.10      **STATISTICAL RESULTS COMPARING THE**  
**OBJECTIVE MEASURES FOR THE FIFTH VISIT FOR**  
**THE TREATMENT AND CONTROL GROUPS**

**TABLE 4.20** Statistical results of the algometric measurements comparing the fifth visit of  
the treatment and control group.

	TREATMENT GROUP VISIT 5			P -VALUE	CONTROL GROUP VISIT 5		
	Me.	S.D.	S.E.		Me.	S.D.	S.E.
ALGOMETER	5.09	2.24	0.41	.003	3.62	1.34	0.24

The two-sample unpaired t-test was used to compare the two groups with respect to each continuous variable ie: Algometer.

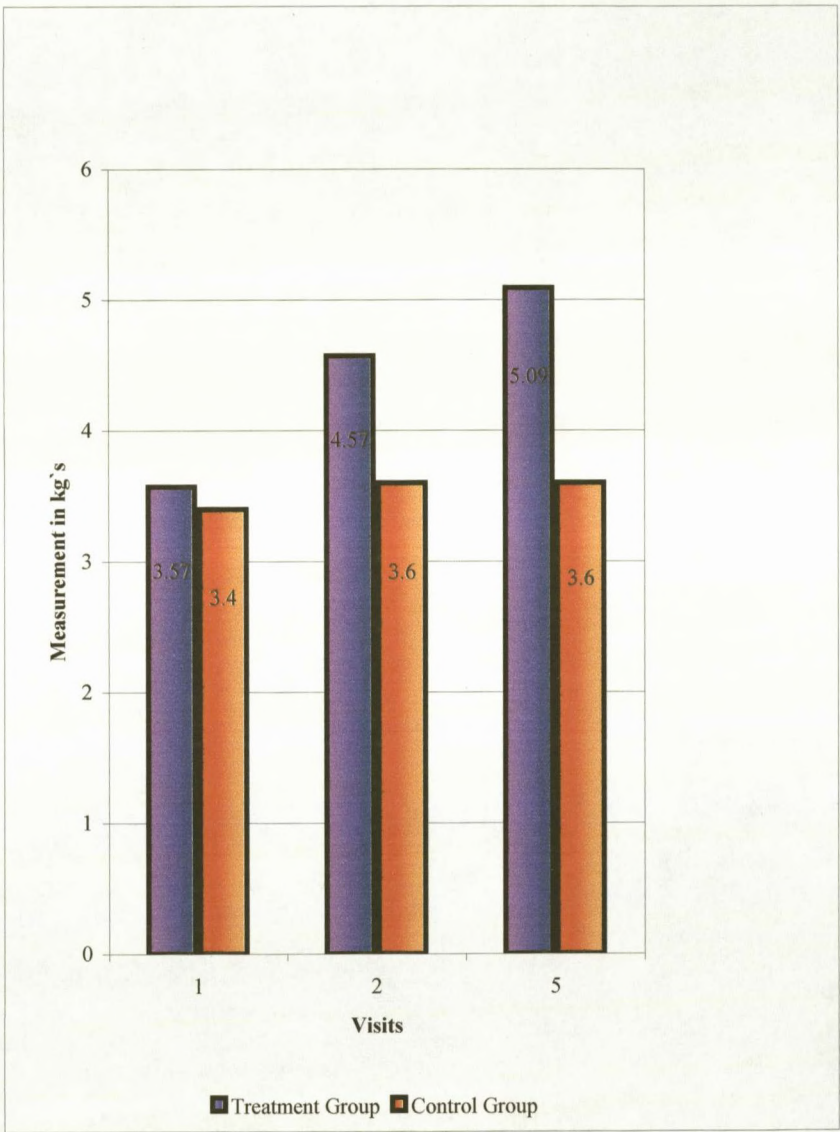
**POWER**

ALGOMETER	100%
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The null hypothesis was rejected for the algometric measurements, indicating a significant  
difference between the treatment and control groups, at the fifth visit.

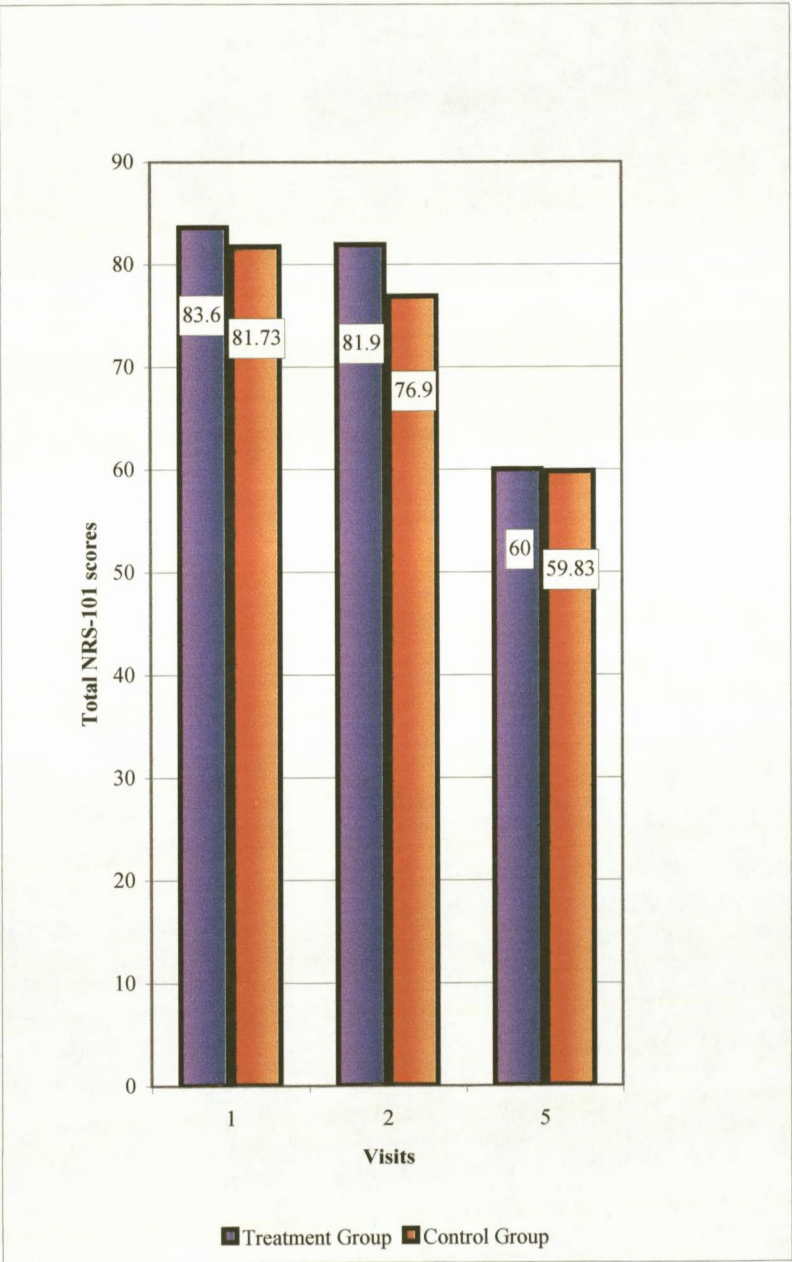
4.7 MEAN VALUES REPRESENTED GRAPHICALLY

FIGURE 4.1 Mean values of the algometric measurements at the first, second and fifth visits comparing the treatment and control groups.



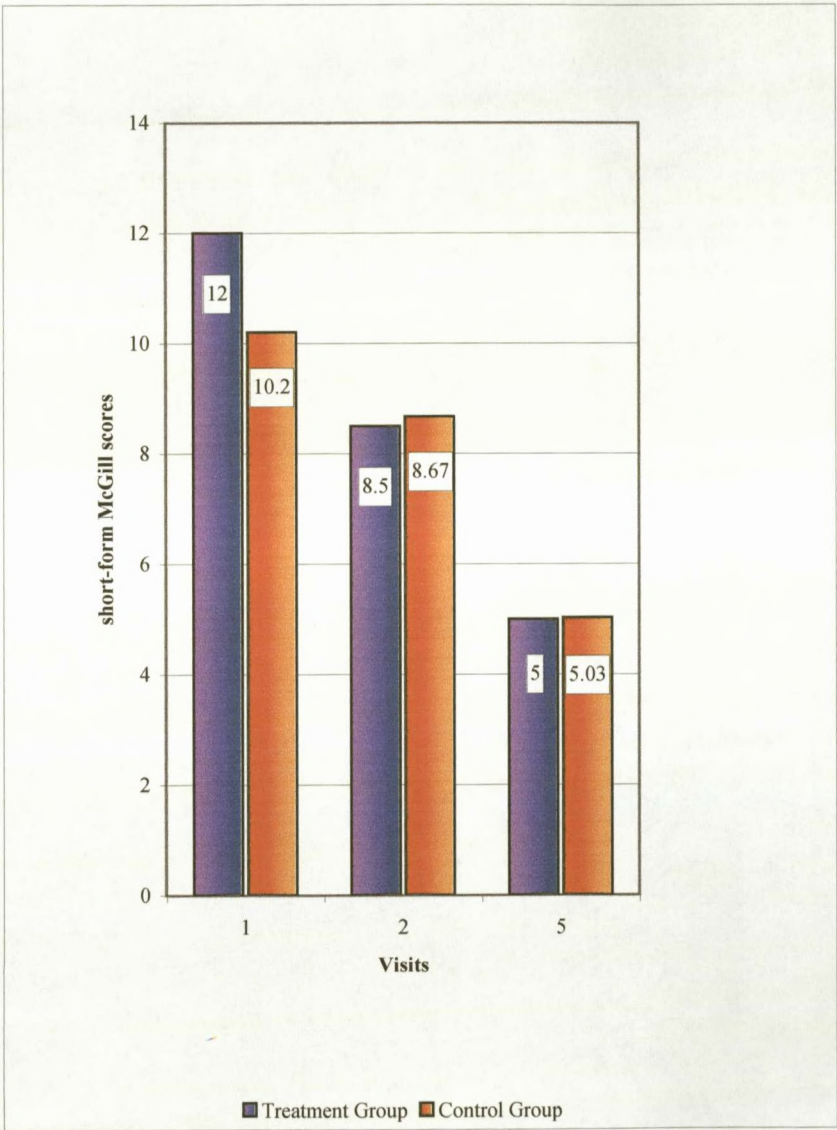


**FIGURE 4.2** Mean values of the total NRS-101 Pain Questionnaire scores at the first, second and fifth visits comparing the treatment and control groups



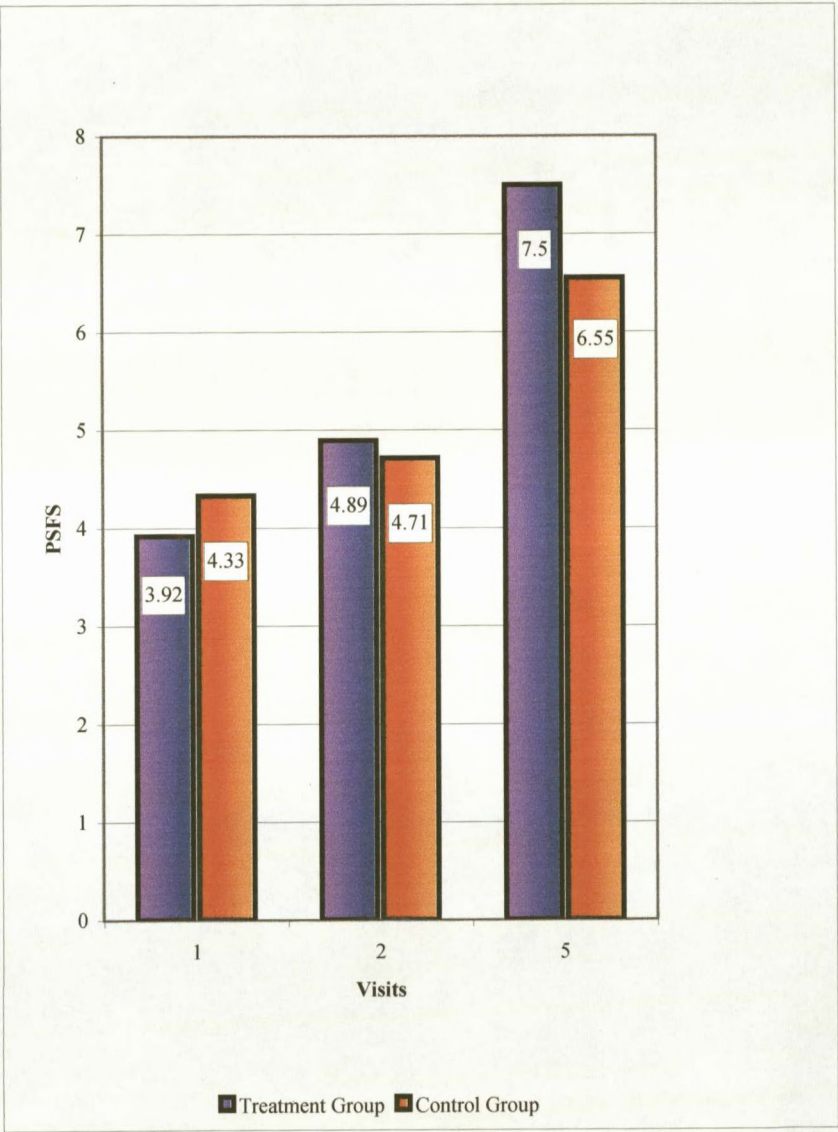


**FIGURE 4.3** Mean values of the short form McGill Pain Questionnaire at the first, second and fifth visits comparing the treatment and control groups





**FIGURE 4.4** Mean values of the Patient Specific Functional Scale at the first, second and fifth visits comparing the treatment and control groups



## CHAPTER 5: DISCUSSION OF THE RESULTS

### 5.1 INTRODUCTION

This chapter involves the discussion of results after statistical analysis of the data obtained from the subjective and objective tests.

The results are discussed in two parts, that is, the objective and subjective results. Each measurement parameter is discussed and involves intra and inter group comparison.

The ranges of age distribution are tabulated in table 4.1.

Of the patients accepted into the study 31% were males, while 29% were females. This denotes a fairly even distribution in terms of gender.

Evaluation of the intra-group results of the first and fifth visits (overall measurement interval) gives an indication of the efficacy of the treatment regime. The comparison of the first and second visits (first measurement interval) and the second and fifth visits (the second measurement interval) are also evaluated to give an indication of any residual benefits of the treatment programme.

Evaluation of inter-group results of the first consultation will reveal any variance in the subjective and objective findings between the two groups presenting at the start of the study.

The assessment and evaluation of the data from the second consultation will reveal any

difference in the rate of improvement between the groups. The comparison of the data collected at the fifth consultation will indicate the effectiveness of the treatment at the conclusion of the study.

## **5.2 OBJECTIVE DATA**

### **5.2.1 INTRA-GROUP COMPARISON**

#### **5.2.1.1 TWO-SAMPLE PAIRED T-TEST**

Upon evaluation of the first, second and overall measurement intervals, there was a significant improvement in the treatment group with respect to algometric measurements (tables 4.9, 4.11 and 4.10).

A significant improvement was also seen in the control group for the first and overall measurement intervals (tables 4.12 and 4.13) but not in the second measurement interval (table 4.14).

These findings suggest that overall, both groups were successful in terms of increasing pressure pain threshold as measured by the algometer. These findings support hypothesis one. It was noted that the improvement seen in both the control group and the treatment group at the first measurement interval showed a greater improvement as compared to the second measurement interval. The mean pressure pain threshold for the treatment group was increased by 1kg/cm squared at the first measurement interval, and by 0.52kg/cm squared at the second measurement interval. Whereas, the mean pressure pain threshold for the control group was increased by 0.18 kg/cm squared at the first measurement interval and by 0.04kg/cm squared

at the second measurement interval for the control group.

These findings indicate that the treatment and control groups had statistically significant improvement in terms of pressure-pain threshold levels at the first and second measurement interval, with the first measurement interval producing the more favorable response. This was thought to be due to the patella mobilization at the first consultation.

## **5.2.2 INTER-GROUP COMPARISON**

### **5.2.2.1 TWO-SAMPLE UNPAIRED T-TEST**

Statistical comparison of the first and second visits showed no significant differences between the groups (tables 4.18 and 4.19). A significant difference was found at the fifth visit (table 4.20). This suggests that at visit five there was a significant difference with regards to the algometric measures between the two groups, that is the treatment group showed a greater improvement in pressure pain threshold. This supports hypothesis two.

It must be noted that although the second visit did not show a statistical difference between the groups, the P-value was 0.031, which approaches a level of statistically significant difference.

## **5.3 SUBJECTIVE DATA**

### **5.3.1 PAIN PERCEPTION (NRS-101)**

#### **5.3.1.1 INTRA GROUP COMPARISON**

##### **5.3.1.1.1 TWO SAMPLE PAIRED T-TEST**

Significant differences were noted for the second and overall measurement interval (tables 4.5 and 4.4) within the treatment group in terms of the NRS-101 questionnaire, while the first measurement interval showed no significant difference (table 4.3).

The control group was found to have a significant improvement at all the measurement intervals. These findings suggest that overall, both groups had a significant decrease in pain perception as measured by the NRS-101 questionnaire. This supports hypothesis one.

#### **5.3.1.2 INTER-GROUP COMPARISON**

##### **5.3.1.2.1 TWO SAMPLE UNPAIRED T-TEST**

No significant difference was noted in the NRS-101 scores when comparing the treatment and control group at all the measurement intervals (tables 4.15, 4.16 and 4.17). This suggests a similarity between the two groups with respect to pain perception as evaluated by the NRS-101. These findings do not support hypothesis two.

## **5.3.2 PAIN PERCEPTION (MC GILL)**

### **5.3.2.1 INTRA GROUP COMPARISON**

#### **5.3.2.1.1 WILCOXON SIGNED RANK TEST**

A significant difference was noted for all measurement intervals for the treatment group (table 4.3, 4.4 and 4.5). The control group demonstrated a significant difference for the second and overall measurement intervals (tables 4.8 and 4.7) but not for the first measurement interval (table 4.6). These findings suggest an overall both groups were effective in terms of decreasing pain perception as shown by the McGill questionnaire. This supports hypothesis one.

### **5.3.2.2 INTER GROUP COMPARISON**

#### **5.3.2.2.1 MANN WHITNEY U TEST**

Evaluation of the results showed no significant differences between the treatment and control groups for the McGill questionnaire at the first, second or fifth visits (tables 4.15, 4.16 and 4.17). These findings suggest a similarity between the groups, which furthermore does not support hypothesis two.

### **5.3.3 DISABILITY AND PAIN (PSFS)**

#### **5.3.3.1 INTRA-GROUP COMPARISON**

##### **5.3.3.1.1 TWO SAMPLE PAIRED T-TEST**

Significant differences were noted for all the measurement intervals for the treatment group (tables 4.3, 4.4 and 4.5). Significant differences were also found for all the measurement intervals for the control group (tables 4.6, 4.7 and 4.8). These findings suggest that both the treatment and control group treatment were effective in reducing knee pain and disability. This supports hypothesis one.

#### **5.3.3.2 INTER GROUP COMPARISON**

##### **5.3.3.2.1 TWO SAMPLE UNPAIRED T-TEST**

Upon evaluation of the results, no significant differences were found between the treatment and control groups at the first, second or fifth visits (tables 4.15, 4.16 and 4.17). This suggests a similarity between the groups, in terms of knee pain and disability as measured by the Patient Specific Functional Scale. This information does not support hypothesis two.

### **5.4 INTERPRETATION OF CLINICAL FINDINGS**

In terms of subjective and objective clinical findings:

Firstly it was hypothesised that combined patella mobilization and “Action Potential Therapy”

would be effective in decreasing the pain and disability in patients with Patellofemoral Pain Syndrome.

In terms of algometric measurements there was an overall improvement in the treatment group. The NRS-101, McGill and PSFS scores showed an overall improvement for both groups. These findings support the above-mentioned hypothesis.

Secondly it was hypothesised that combined patella mobilization and “Action Potential Therapy” would be more effective than combined patella mobilization and placebo “Action Potential Therapy” in the management of patients with Patellofemoral Pain Syndrome.

In terms of algometric measurements there was a significant difference between the groups at the fifth visit, supporting the second hypothesis in terms of objective findings. In terms of subjective findings, no significant difference was found between the groups, this does not support the second hypothesis.

## **5.5 POWER VALUES**

Power values were calculated for the intra-group continuous variables, namely: the algometer readings, the NRS-101 scores and the PSFS scores. It was assumed that for this study that there was a greater chance of accepting the a type II error when the power value was less than 50%.



## 5.6 PROBLEMS ENCOUNTERED WITH THE DATA

### 5.6.1 THE OBJECTIVE DATA

Two problems were encountered with the use of the algometer as an objective tool.

- Some patients felt bruised after the usage of the algometer and may therefore have shown a relatively small improvement in objective findings or have responded to lower pressure to prevent further bruising.
- It was felt that although the same point was used to take the algometer readings certain factors could affect the outcome namely direction of pressure applied through the shaft of the algometer, skin slack and the emotional state of the patient.

### 5.6.2 THE SUBJECTIVE DATA

In utilizing questionnaires one has to take into account two types of error. Type I errors occur when the patients answer the questionnaires based on what they recall filling in on previous questionnaires, while type II errors are calculation errors with regards to questionnaire results.

## CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

### 6.1 CONCLUSION

The study consisted of 60 patients diagnosed with Patellofemoral Pain Syndrome (PFPS). All patients underwent a full case history and knee regional examination. The patients were randomly allocated into a treatment (group 1) and control group (group 2). Patients were required to attend the clinic 5 times over a period of approximately 2 weeks. Patients were treated on visit 1,2,3 and 4 with data being collected on visits 1,2 and 5. Group one received patella mobilization and Action Potential Therapy (APT) whilst group two received patella mobilization and placebo APT. Patients received one treatment of combined patella mobilization and APT or placebo APT followed by three treatments consisting only of APT or placebo APT.

The results indicated that both groups were effective overall in increasing the patients' pressure pain threshold. Pain perception (NRS-101) was improved for both groups overall. An overall improvement in Pain perception (McGill) was seen in both groups, furthermore an improvement in disability and pain (PSFS) was seen in both groups.

No significant differences were found between the groups for the subjective measures, a statistically significant difference was however found between the algometric measures of the fifth visit indicating a greater improvement within the treatment group in terms of pressure pain threshold.

Both treatments were found to be effective, with the treatment group showing a statistically significant difference in the objective measure at the fifth visit when compared to the control group. This study therefore supports the use of combined patella mobilization and "Action Potential Therapy" in the short term treatment of Patellofemoral Pain Syndrome.

This treatment may be enhanced by the prescription of appropriate exercises and avoidance of aggravating factors and by the employment of other treatment regimes.

Rowlands (1999) in a placebo controlled study on mobilization of the patella found that the intragroup comparison showed the treatment group to have a greater response than the placebo group. The intergroup comparison revealed a statistically significant difference in objective findings (P-value 0.0086 and 0.0061). Improvement in intergroup subjective data was not found to be statistically significant. The study was relatively small with 15 subjects in each group. The results of this study compared favorably to Rowlands' (1999) study.

This study was a pilot study and may be used as a foundation for further studies on the chiropractic treatment of PFPS

## 6.2 RECOMMENDATIONS

The following recommendations are made for future studies:

### Sample size:

It is not clear what the population parameters are for PFPS in South Africa, we therefore have to accept that a fairly high level of sampling error may be present and therefore to decrease the sampling error to 10% 100 observations would be optimal (De Vaus, 1996: 71). From the study it was however evident that casual inferences could be drawn from the sample size used with adequate power.

### Homogeneity:

Stricter inclusion and exclusion criteria with regards to the case history and physical findings, would enhance the strength of the study.

### Blinding:

Double blinding was attempted by randomly assigning patients to either placebo or active APT. The units were marked "a,b,c, and d" by the manufacturer and the true nature of the units revealed after all the data had been collected.. The researcher was partially unblinded by the patient response to treatment with patients in the placebo group indicating that they felt no sensation with therapy, whilst the active group claimed to feel something. The treatments could be administered by an unbiased colleague to prevent the researcher from "figuring out" by means of the patients' sensory response, which units are active or placebo.

#### Data measurement:

Significant changes may be detected with more advanced technology that is more accurate and sensitive or specific, thereby possibly allowing more accurate results and more significant findings. Furthermore the use of an unbiased, blinded colleague to record the subjective and objective data may provide more reliable and unbiased data and increase the credibility of the study.

#### Treatment time:

The use of treatment time greater than 8 minutes to explore the best duration of treatment.

#### Follow up consultation:

The inclusion of a follow up consultation a few weeks after the completion of the study to assess medium term effects of treatment.

#### Intensity of treatment:

In this study the current intensity was not allowed to exceed 2mA. The usage of a current as high as the patients' comfort will allow is recommended. Berger (1999: 63) states that the higher the intensity, the greater the improvement of the condition with the objective being to encourage as high as intensity as possible always allowing the comfort of the patient.

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**TECHNIKON NATAL CHIROPRACTIC DAY CLINIC**  
**CASE HISTORY**

Patient: \_\_\_\_\_ Date: \_\_\_\_\_  
 file #: \_\_\_\_\_ X-Ray#: \_\_\_\_\_  
 Age: \_\_\_\_\_ Sex: \_\_\_\_\_ Occupation: \_\_\_\_\_  
 Intern: \_\_\_\_\_ Signature: \_\_\_\_\_

**FOR CLINICIAN'S USE ONLY**

Initial visit clinician: \_\_\_\_\_ Signature: \_\_\_\_\_

**Case History:**

**Examination:**

Previous:

Current:

**X-Ray Studies:**

Previous:

Current:

**Clinical Path. lab:**

Previous:

Current:

**Case Status:**

PTT:            Conditional:            Signed Off:            Final Sign out:

Recommendations:

Intern's Case History

1. Source of History:
2. Chief Complaint: (patient's own words)

3. Present Illness:

- ▶ Location
- ▶ Onset
- ▶ Duration
- ▶ Frequency
- ▶ Pain (Character)
- ▶ Progression
- ▶ Aggravating Factors
- ▶ Relieving Factors
- ▶ Associated S & S
- ▶ Previous Occurrences
- ▶ Past Treatment and Outcome

4. Other Complaints:

5. Past Medical History:

- ▶ General Health Status
- ▶ Childhood Illnesses
- ▶ Adult Illnesses
- ▶ Psychiatric Illnesses
- ▶ Accidents/Injuries
- ▶ Surgery
- ▶ Hospitalizations

6. Current health status and life-style:

- ▶ Allergies
- ▶ Immunizations
- ▶ Screening Tests
- ▶ Environmental Hazards (Home, School, Work)
- ▶ Safety Measures (seat belts, condoms)
- ▶ Exercise and Leisure
- ▶ Sleep Patterns
- ▶ Diet
- ▶ Current Medication
- ▶ Tobacco
- ▶ Alcohol
- ▶ Social Drugs

7. Immediate Family Medical History:

- ▶ Age
- ▶ Health
- ▶ Cause of Death
- ▶ DM
- ▶ Heart Disease
- ▶ TB
- ▶ Stroke
- ▶ Kidney Disease
- ▶ CA
- ▶ Arthritis
- ▶ Anaemia
- ▶ Headaches
- ▶ Thyroid Disease
- ▶ Epilepsy
- ▶ Mental Illness
- ▶ Alcoholism
- ▶ Drug Addiction
- ▶ Other

8. Psychosocial history:

- ▶ Home Situation and daily life
- ▶ Important experiences
- ▶ Religious Beliefs

9. Review of Systems:

- ▶ General
- ▶ Skin
- ▶ Head
- ▶ Eyes
- ▶ Ears
- ▶ Nose/Sinuses
- ▶ Mouth/Throat
- ▶ Neck
- ▶ Breasts
- ▶ Respiratory
- ▶ Cardiac
- ▶ Gastro-intestinal
- ▶ Urinary
- ▶ Genital
- ▶ Vascular
- ▶ Musculoskeletal
- ▶ Neurologic
- ▶ Haematologic
- ▶ Endocrine
- ▶ Psychiatric

Patient: \_\_\_\_\_ File No.: \_\_\_\_\_ Date: \_\_\_\_\_  
 Intern / Resident: \_\_\_\_\_ Signature: \_\_\_\_\_  
 Clinician: \_\_\_\_\_ Signature: \_\_\_\_\_

**OBSERVATION:**

- General: - posture and gait \_\_\_\_\_  
 - skin (scars, bruises) \_\_\_\_\_  
 - swelling / bony enlargements \_\_\_\_\_
- Anterior: - genu varum / valgum \_\_\_\_\_  
 - patella position \_\_\_\_\_  
 - tibial torsion \_\_\_\_\_  
 - symmetrical extension \_\_\_\_\_
- Lateral - genu recurvatum \_\_\_\_\_  
 - patella alta / baja \_\_\_\_\_  
 - symmetrical extension \_\_\_\_\_
- Posterior: - swelling \_\_\_\_\_
- Seated: - patella position \_\_\_\_\_  
 - tibial tubercle \_\_\_\_\_  
 - tibial torsion (toe-in / toe-out) \_\_\_\_\_

**PALPATION:**Anterior :

- patella - base, apex, pre-patella bursa \_\_\_\_\_
- retinaculum, cartilagenous surface \_\_\_\_\_
- patella tendon, infrapatella bursa, fat pad, tibial tuberosity \_\_\_\_\_
- quadriceps tendon, suprapatella pouch \_\_\_\_\_
- quadriceps and sartorius \_\_\_\_\_

Medial:

- MCL, medial joint line, pes anserinus \_\_\_\_\_

Lateral:

- LCL, lateral joint line, TFL, ITB, head of fibula \_\_\_\_\_

Knee flexed 45° + 90°:

- joint line, tibial plateaux, menisci, femoral condyles \_\_\_\_\_
- adductor tubercle and adductor muscles \_\_\_\_\_

Posterior:

- Popliteal artery \_\_\_\_\_
- Lateral - lateral meniscus, arcuate popliteus complex \_\_\_\_\_  
 - lateral head gastrocnemius, biceps femoris \_\_\_\_\_
- Medial - medial meniscus, posterior oblique ligament \_\_\_\_\_  
 - medial head gastroc, semimembranosis, semitendonsis \_\_\_\_\_

## ACTIVE MOVEMENTS:

- Flexion (0-35°) \_\_\_\_\_
- Extension (0-15°) \_\_\_\_\_
- Medial rotation (20-30°) \_\_\_\_\_
- Lateral rotation (30-40°) \_\_\_\_\_

## PASSIVE MOVEMENTS:

page 2 of 3

- Flexion (tissue approximation) \_\_\_\_\_
- Extension (bone to bone) \_\_\_\_\_
- Medial rotation (tissue stretch) \_\_\_\_\_
- Lateral rotation (tissue stretch) \_\_\_\_\_

## RESISTED ISOMETRIC MOVEMENTS:

- Flexion (neutral, int rot, ext rotation) \_\_\_\_\_
- Extension (0°, 30°, 60°, 90°) \_\_\_\_\_
- Medial rotation \_\_\_\_\_
- Lateral rotation \_\_\_\_\_
- Ankle plantarflexion \_\_\_\_\_
- Ankle dorsiflexion \_\_\_\_\_

## FUNCTIONAL TESTS: \_\_\_\_\_

## JOINT PLAY MOVEMENTS

- P-A / A-P movement of tibia on femur \_\_\_\_\_
- Medial / lateral translation of tibia on femur \_\_\_\_\_
- Long-axis distraction of tibio-femoral joint \_\_\_\_\_
- Patella movement (sup-inf, med-lat) \_\_\_\_\_
- P-A / A-P movement of superior tib-fib joint \_\_\_\_\_

## LIGAMENTOUS ASSESSMENT:

- One-plane medial instability (valgus stress)
  - extended \_\_\_\_\_
  - resting position \_\_\_\_\_
- One-plane lateral instability (varus stress)
  - extended \_\_\_\_\_
  - resting position \_\_\_\_\_
- One-plane anterior instability
  - Lachman (0-30°) \_\_\_\_\_
  - anterior draw (90°) \_\_\_\_\_
- One-plane posterior instability
  - posterior sag sign (90°) \_\_\_\_\_
  - posterior draw (90°) \_\_\_\_\_
- Antero-lateral rotary instability
  - Slocum \_\_\_\_\_
  - Macintosh (lat. pivot shift) \_\_\_\_\_
- Antero-medial rotary instability
  - Slocum \_\_\_\_\_
- Postero-lateral rotary instability
  - Houghston's drawer \_\_\_\_\_
- Postero-medial rotary instability
  - Houghston's Drawer \_\_\_\_\_

**TESTS FOR MENISCAL PATHOLOGY:**

- McMurray \_\_\_\_\_
- Bounce-Home \_\_\_\_\_
- Anderson's Grind \_\_\_\_\_
- Apley's \_\_\_\_\_

**PLICA TESTS**

- Mediopatellar plica \_\_\_\_\_
- Plica stutter \_\_\_\_\_
- Houghston's Plica \_\_\_\_\_

**SWELLING**

- Brush / stroke test \_\_\_\_\_
- Patella tap test \_\_\_\_\_

**TESTS FOR PATELLO-FEMORAL PAIN SYNDROME**

- Clarke's sign \_\_\_\_\_
- Waldron test \_\_\_\_\_
- Passive patella tilt \_\_\_\_\_

**OTHER TESTS:**

- Wilson's test (osteochondritis dessicans) \_\_\_\_\_
- Fairbank's test (dislocated patella) \_\_\_\_\_
- Noble compression test (ITB friction) \_\_\_\_\_
- Quadriceps contusion test \_\_\_\_\_
- Leg length \_\_\_\_\_

**NEUROLOGICAL:**

- Reflexes
  - Patella (L3/4) R \_\_\_\_\_ L \_\_\_\_\_
  - Medial hamstring (L5/S1) R \_\_\_\_\_ L \_\_\_\_\_
- Dermatomes
  - L1 \_\_\_\_\_ L2 \_\_\_\_\_ L3 \_\_\_\_\_ L4 \_\_\_\_\_ L5 \_\_\_\_\_
  - S1 \_\_\_\_\_ S2 \_\_\_\_\_

**RADIOLOGICAL EXAMINATION:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**DIAGNOSIS:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**MANAGEMENT PLAN:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



\*Delete that which is not applicable.  
INFORMED CONSENT FORM

## TITLE OF RESEARCH PROJECT

The relative effectiveness of Action Potential Therapy and patella mobilization versus placebo Action Potential Therapy and patella mobilization in the treatment of Patellofemoral Pain Syndrome.

## NAME OF SUPERVISOR

Dr Myburgh

## NAME OF RESEARCH STUDENT

Jenifer Goldberg

DATE: \_\_\_\_\_

## PLEASE CIRCLE THE APPROPRIATE ANSWER

- |  |        |
|--|--------|
| 1) Have you read the research information sheet?                         | YES/NO |
| 2) Have you had an opportunity to ask questions regarding the study?     | YES/NO |
| 3) Have you received satisfactory answers to your questions?             | YES/NO |
| 4) Have you had an opportunity to discuss this study?                    | YES/NO |
| 5) Have you received enough information about this study?                | YES/NO |
| 6) Who have you spoken to? _____   |        |
| 7) Do you understand the implications of your involvement in this study? | YES/NO |
| 8) Do you understand that you are free to withdraw from this study       |        |
| a) at any time   |        |
| b) without having to give reason for withdrawing, and                    |        |
| c) without affecting your future health care?                            | YES/NO |
| 9) Do you agree to voluntarily participate in this study?                | YES/NO |

If you have answered no to any of the above please ensure you are informed as to the relevant sections.

PATIENT/SUBJECT\* Name \_\_\_\_\_  
(In block letters)

Signature \_\_\_\_\_

PARENT/GUARDIAN\* Name \_\_\_\_\_

Signature \_\_\_\_\_

WITNESS Name \_\_\_\_\_

Signature \_\_\_\_\_

RESEARCH STUDENT JENIFER GOLDBERG

Signature \_\_\_\_\_

APPENDIX D  
PATIENT SPECIFIC FUNCTIONAL SCALE

Date: \_\_\_\_\_

File no: \_\_\_\_\_

Patient name: \_\_\_\_\_

Identify up to five important activities that you are unable to perform or have difficulty with as  
as a result of your \_\_\_\_\_ (indicate the specific area of injury) injury.

Rate each activity according to the scale given below.

1    2    3    4    5    6    7    8    9    10

Unable  
to perform activity

Able to perform  
activity at same  
level as before  
injury or problem

Activity	Initial	Second visit	Fifth visit
----------	---------	--------------	-------------

1) _____			
----------	--	--	--

2) _____			
----------	--	--	--

3) _____			
----------	--	--	--

4) _____			
----------	--	--	--

5) _____			
----------	--	--	--

Numerical Rating Scale - 101 Questionnaire

Date: \_\_\_\_\_

Patient name: \_\_\_\_\_

File number: \_\_\_\_\_

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience *when it is at its worst*. A zero (0) would mean "no pain at all", and one hundred (100) would mean "pain as bad as it could be".

Please write only the number.

\_\_\_\_\_

Please indicate on the line below, the number between 0 and 100 that best describes the pain you experience *when it is at its least*. A zero (0) would mean "no pain at all" and one hundred (100) would mean "pain as bad as it could be".

Please write only the number.

\_\_\_\_\_



## APPENDIX F

**SHORT-FORM MCGILL PAIN QUESTIONNAIRE**

PATIENT NAME: \_\_\_\_\_ FILE NO.: \_\_\_\_\_

DATE: \_\_\_\_\_ TREATMENT NO.: \_\_\_\_\_

THROBBING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

SHOOTING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

STABBING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

SHARP 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

GRAMPING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

GNAWING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

HOT-BURNING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

ACHING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

HEAVY 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

TENDER 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

SPLITTING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

TIRING-EXHAUSTING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

SICKENING 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

FEARFUL 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_

PUNISHING-CRUEL 0) \_\_\_\_\_ 1) \_\_\_\_\_ 2) \_\_\_\_\_ 3) \_\_\_\_\_