



## Protocols

### Patellofemoral Pain

James Selfe 1

## Patellofemoral Pain Syndrome Protocol.

Using the NeuroTrac 5™ EMG Biofeedback for Rehabilitation the Vastus Medialis in Patients with Patellofemoral Pain.

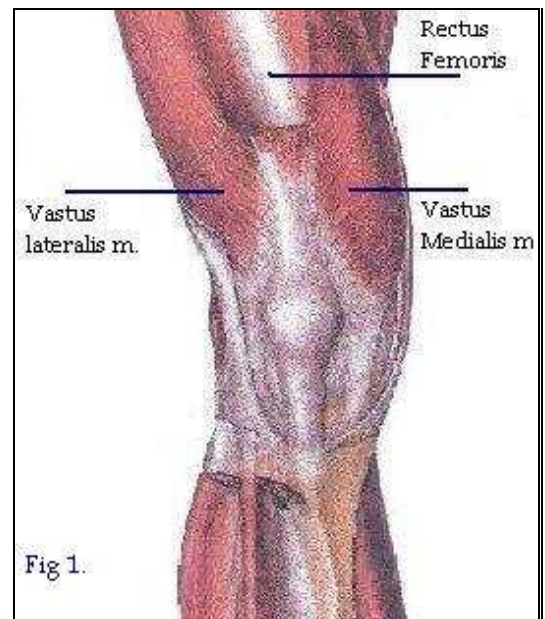
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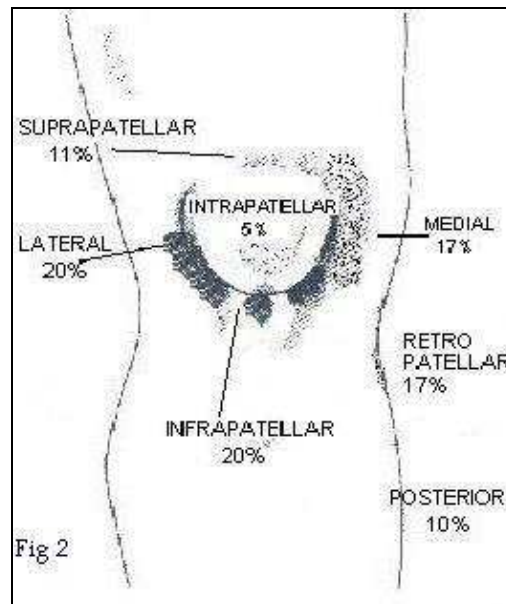
### Background Information.

Patellofemoral pain (PFP) is reported to be the most common symptom complex in the knee joint, ([Tria et al 1992](#)). However, there are many unknown features of the condition and there is no consensus view on appropriate management [Noyes \(1986\)](#) describes the diagnosis and treatment of patellofemoral problems as the 'Black Box of orthopedics. [Dye and Vaupel \(1994\)](#) echo this sentiment using the description of the 'Orthopedic Black Hole' when describing the challenging nature of patellofemoral problems. The lack of consensus in the management of the problem is illustrated by [Maenpaa & Lehto \(1997\)](#), who report that there are over 100 surgical procedures just to correct patella dislocation.

PFP often has an insidious onset, typically related to repetitive microtrauma. The incidence in the general population is claimed to be as high as 1:4 and even higher in athletes [Outerbridge \(1964\)](#) and [Levine \(1979\)](#). However in a two-year prospective study of 282, nineteen year old Physical Education students only 24 (9%), 16 female and 8 males, developed patellofemoral problems ([Witvrouw et al 1999](#)). The female: male ratio is reported as 3:2. Traditionally the condition has been associated with the adolescent, but it should be considered in any age groups. In a study of 41 NHS Orthopedic outpatients with patellofemoral problems,



The mean age was 31 (range 15 - 40). (Selfe, Gillard & Marshall 1996). Cushman, McCarthy and Dieppe (1994) studied a group of patients whose mean age was 70.4 years (range 55-84). The pain is characterized by a diffuse dull ache punctuated with periods of sharp pain in the vicinity of the patella. It can, however, be felt anywhere around the knee (Figure 2).



Data from 119 Knees. (Selfe, Harper, Pedersen, Wareing & Breen-Turner)

The pain is often aggravated by sports, stairs, prolonged sitting (Moviegoers Knee in Australia and the Theatre sign in USA), driving and in severe cases by walking.

Commonly the condition presents bilaterally, in a study of 77 patients, forty-two (55%) presented with bilateral problems (Selfe et al, manuscript with reviewers).

There is often a low-grade effusion associated with PFP, Spencer and Hayes (1984) found that 20 mls of saline will inhibit the vastus medialis obliquus (VMO) and 50 /60 mls will inhibit both Rectus Femoris and Vastus Lateralis. Iles et al (1990) suggests that any degree of joint effusion will have an inhibitory effect on the quadriceps. However, Herrington (1998) in a review states that "joint effusion is not of primary importance in creating muscle inhibition."

The source of pain, in patients with patellofemoral pain is controversial; the articular cartilage of the patella cannot be a source as it is avascular and aneural (Fulkerson & Hungerford 1990 and Williams et al 1995). It is also reported that in cases where patellectomy has been performed pain regularly persists (Macnicol, 1995). It may be that in these cases some central neural changes have established a chronic pain syndrome. Dye et al (1999); suggest the most likely causes of pain in patellofemoral syndromes are innervated peripatellar soft tissues and the patellar bone, itself.

Numerous studies have attempted to link patellofemoral pain syndromes with faulty lower limb mechanics, however, results have been equivocal and no consensus has yet been reached (Kannus & Nittymaki 1994, Blond & Hansen 1998, Natri et al 1998).

Another area of research that has attracted a lot of attention is the role of the VMO. Lieb and Perry (1971) described the Vastus Medialis as being divided into 2 distinct parts, the Vastus Medialis Obliquus (VMO) and the Vastus Medialis Longus (VML), both having an independent nerve supply from the femoral nerve. Controversially it is reported that the VMO also receives a separate motor innervation from the saphenous nerve (Gunal et al 1992).

Gerrard (1989), reports that the VMO takes origin not only from the femur but also from the Adductor Magnus and Adductor Longus tendon and that it inserts to the patella at an angle of 55-70 to the long axis of the femur. According to Laprade et al (1998), the VMO also has attachments directly onto the tibia and is capable of assisting internal rotation of the tibia. The traditional view of the function of the VMO is that it aligns the patella medially during extension of the knee. It is the only dynamic medial stabiliser of the patella and any insufficiency of this muscle will increase the lateral drift of the patella, which may lead to PFP. However the role of the VMO, in contributing to PFP remains an area of hot debate for further discussion on this see Callaghan (1996) and Herrington (1998). Recently an anatomical study has thrown considerable doubt on the role of the VMO in PFP. Hubbard et al (1998), following 374 dissections on adult cadavers report that the VMO and VML do not exist as anatomically separate structures.

## Biofeedback

In the musculoskeletal field biofeedback makes use of the electromyographic or (EMG) signal, this is the electrical activity associated with a contracting muscle, (Craig & Oatis 1994).

## Electrodes

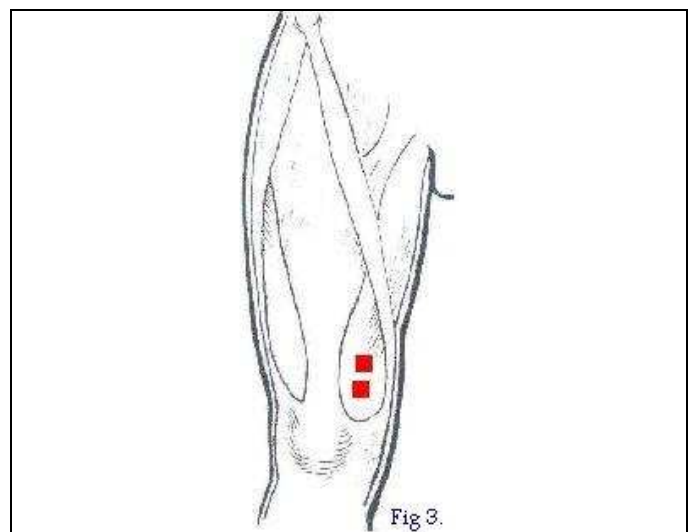
In order to detect the EMG signal, electrodes are placed either within the muscle tissue or on the skin overlying the muscle. The advantages of surface electrodes are that they are simple and painless to apply and they provide a composite picture of the activity of underlying motor units. Their disadvantages are that they are likely to pick up electrical activity occurring in muscles other than the target muscle; this is called cross talk, (Currier 1984). Also if the electrode is not in good contact with the skin or the equipment is used too close to other electrical equipment there is likely to be interference, (Turka 1993).

## Electrode Placement

The greatest EMG signal will be picked up by placing the electrodes as close as possible to the center of the fleshy muscle mass of the specific muscle. The greatest signal is recorded when the electrodes are placed on a longitudinal axis in the direction of the muscle fibres. The average voltage drops by up to 35% when a comparable transverse sitting is used, Gilmore & Meyers (1983).

Figure 3

Optimal electrode placement site for the quadriceps (Basmajian and Blumenstein 1980).



Biofeedback provides instant feedback as to whether the exercise was performed correctly. This is particularly useful in the early stages of rehabilitation when the exercises are not particularly easy to perform and accurate performance is vital.

- **Instant feedback**

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- **Shaping**

This is achieved by adjusting the threshold setting of the machine. In patellofemoral problems positive shaping is used where the threshold of the machine is turned up as the patient progresses. This will help to elicit a stronger contraction in order to reach the required level of feedback. Patients can be made to work very hard using this process however; the pain response must be respected at all times. If pain or undue fatigue occurs then the exercise needs to be modified or stopped.

- **Identifies poor phases of contraction.**

Biofeedback enables the therapist to determine whether the contraction is being sustained over the chosen time period during isometric exercises and that the contraction is sustained during both concentric and eccentric phases of an isotonic exercise. This is very useful in patellofemoral problems, as these patients will often display a specific eccentric deficit. Identifying when and where this deficit occurs enables the therapist to use very specific rehabilitation techniques.

- **Auditory Feedback**

This is used in isolation during the early stages of the rehabilitation program when patients are performing proprioceptive exercises with their eyes closed.

- **Visual Feedback**

Encouraging patients to follow specific movement patterns using Templates on the computer screen is used in the intermediate stages of rehabilitation. This is where patients perform functionally relevant movement patterns at controlled speeds.

- **Objective Measurement**

Quantitative scoring of EMG activity is desirable for 2 main reasons. Firstly, it allows the therapist to evaluate the patient's progress over a number of training sessions and to decide whether further training is likely to produce worthwhile gains in function. Secondly, it is helpful to the patient to know what progress he/she has made relative to other training sessions as well as receiving feedback during the session. This information is itself a form of feedback and knowledge of previous results is an effective way of maintaining a high level of motivation.

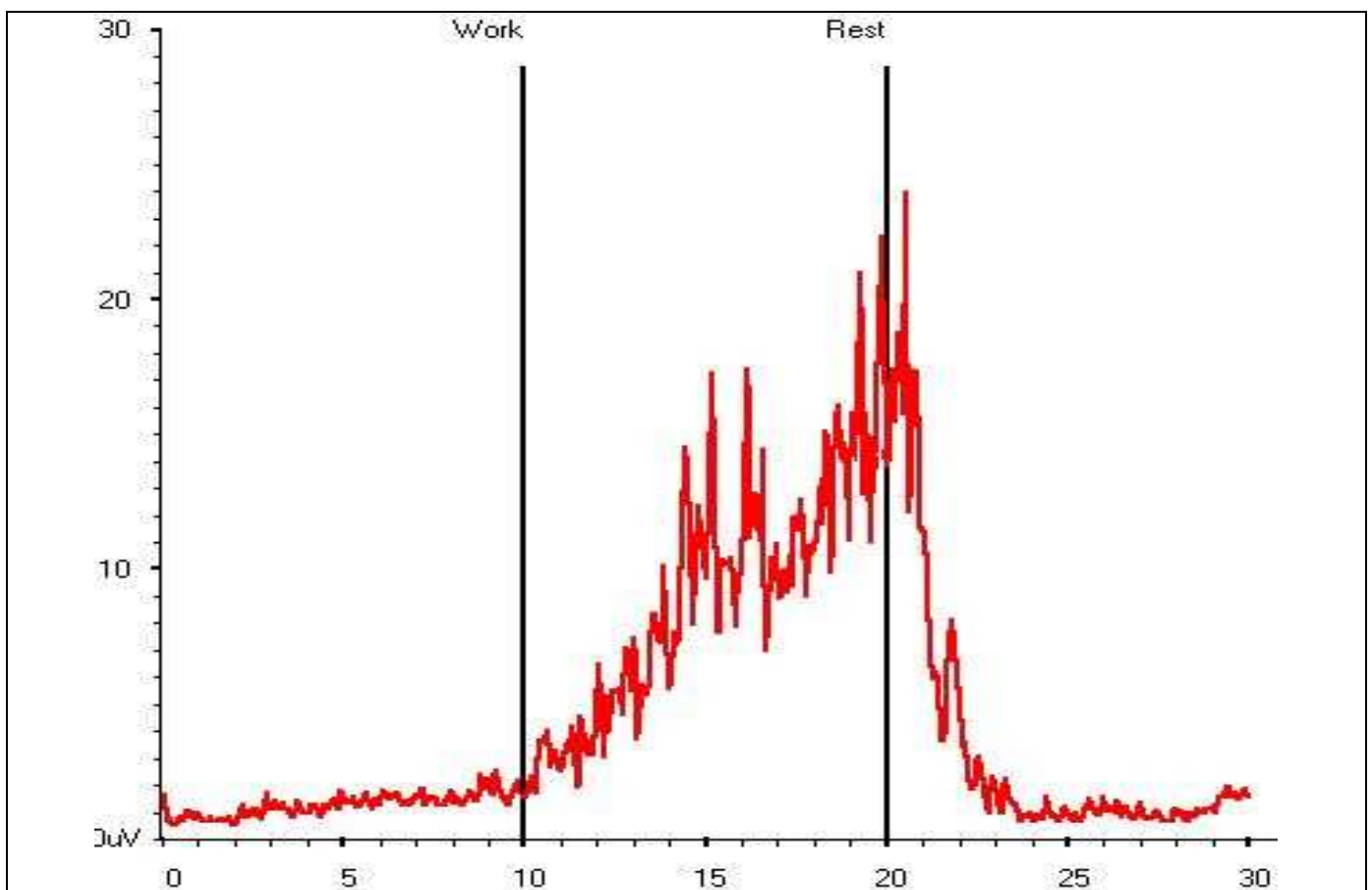
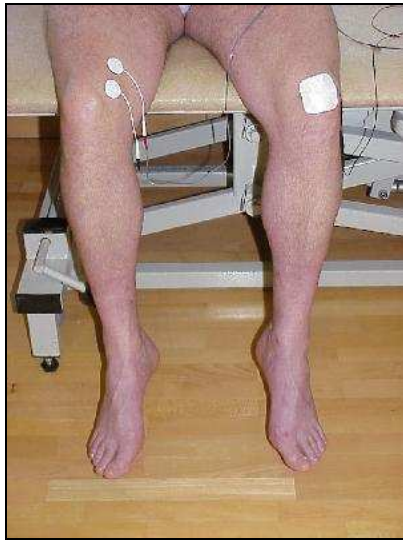
**Exercise Regime.**

When the patient is being taught the exercises it is important to warn them that they must not try and work through pain or excessive fatigue. If there is pain the muscles will be inhibited and they will not respond to the training. The exercises are performed at least twice a day and then as a maintenance routine once per day. The patients will have to self-review every few months to make sure that they are not slipping back again. Both the patient and therapist should recognise that a plateau of progress is likely to occur and that the exercise program should not be abandoned.

The exercises can be progressed in a number of ways. The number of sets or repetitions can be increased. The length of time each component of the exercise is maintained for can be increased. With the weight bearing exercises bar bells or rucksacks with weights can be used. To increase proprioceptive input weight-bearing exercises can be performed with the eyes closed.

Initially I usually teach patients both of the sitting exercises. If possible, I then review them 2/3 days later. I then check the performance of these exercises, if satisfactory I then teach them additional exercises, the number of new exercises depends on the irritability of the patients joint and the patients likely level of compliance. The patient is then reviewed between 7-14 days, each time new exercises being given if progress is satisfactory.

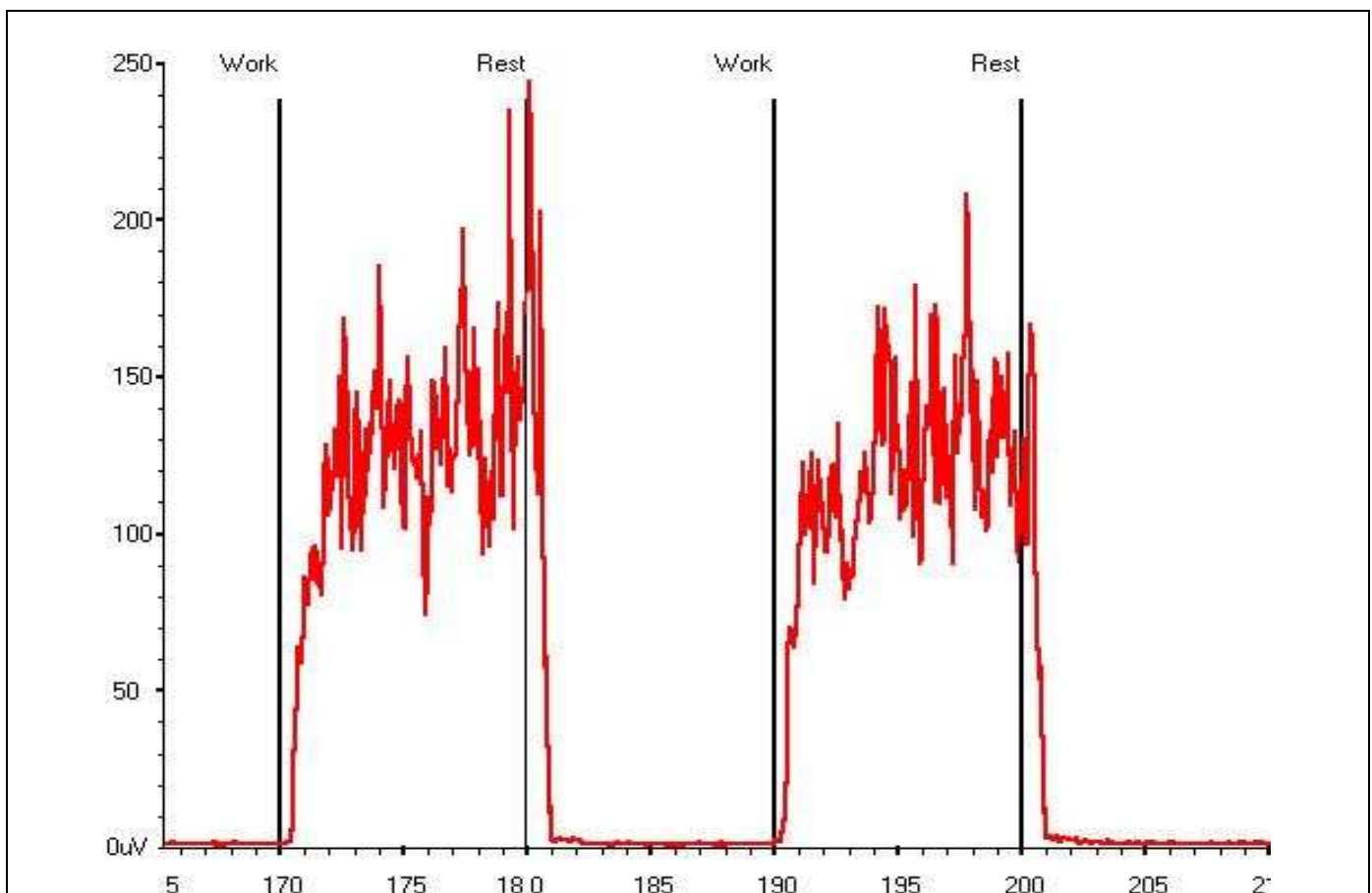
The following exercises are just a sample and are considered, as the basic building blocks, it is important to remember that there is little cross over between training activities and functional activities (Newham 1993). Any exercises should be as functional as possible for the individual, and functional exercises should be introduced as early as possible in the rehabilitation process. The following exercises can be performed with the NeuroTrac 5<sup>TM</sup> electrodes over the vastus medialis (Figure 3). Whilst performing these exercises the patients are instructed to focus their attention on achieving a predetermined amount of EMG activity.

**EXERCISE 1:**

EMG Graph of a healthy 52 year old male who regularly cycles and walks.

**EXERCISE 2:**

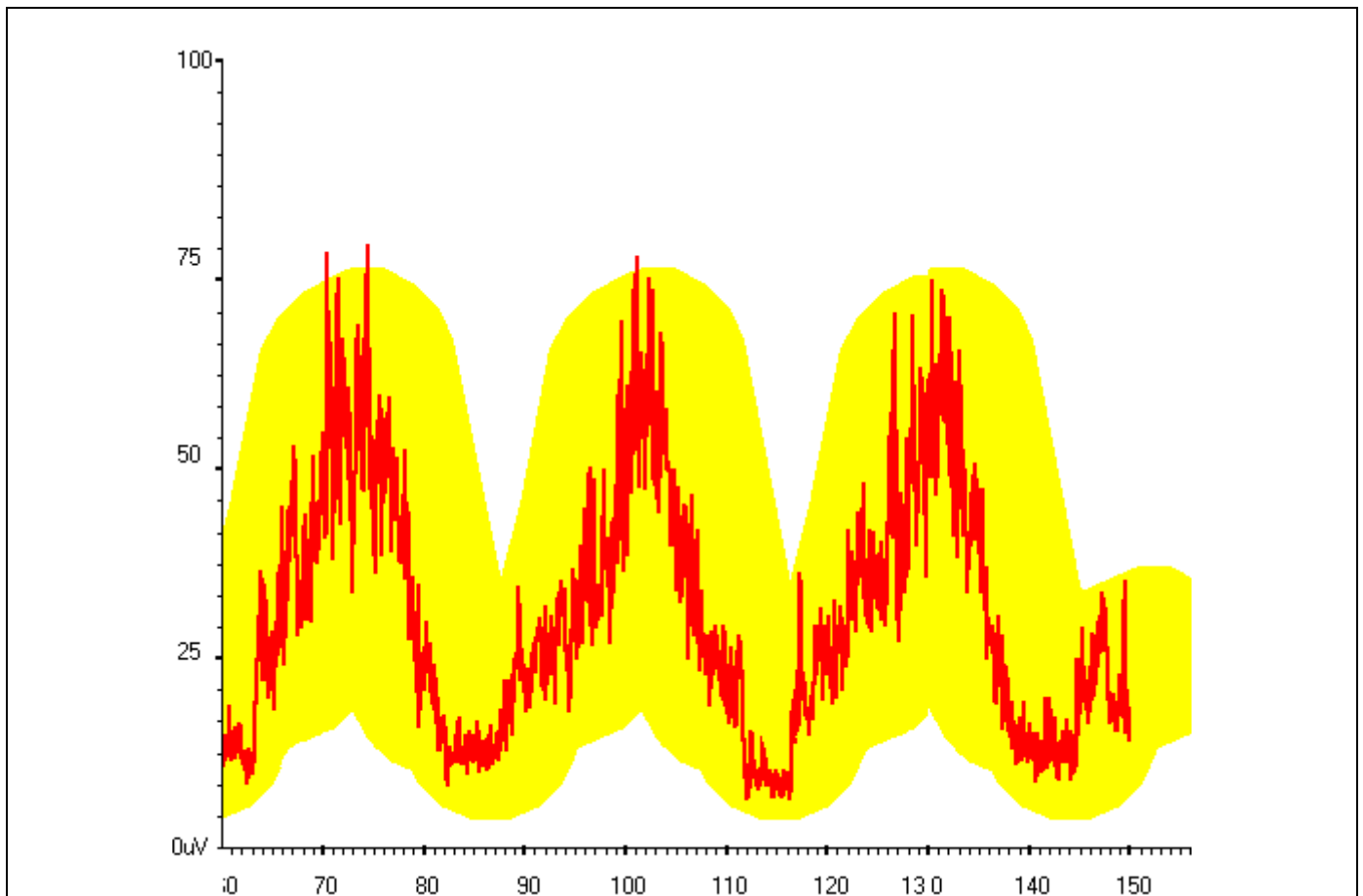
In sitting (knees approximately 10-20cm apart) push the inside of your heel down and forwards into the floor. Hold for 10 seconds. Repeat x10.



EMG Graph of a healthy 52 year old male who regularly cycles and walks.

**EXERCISE 3:**

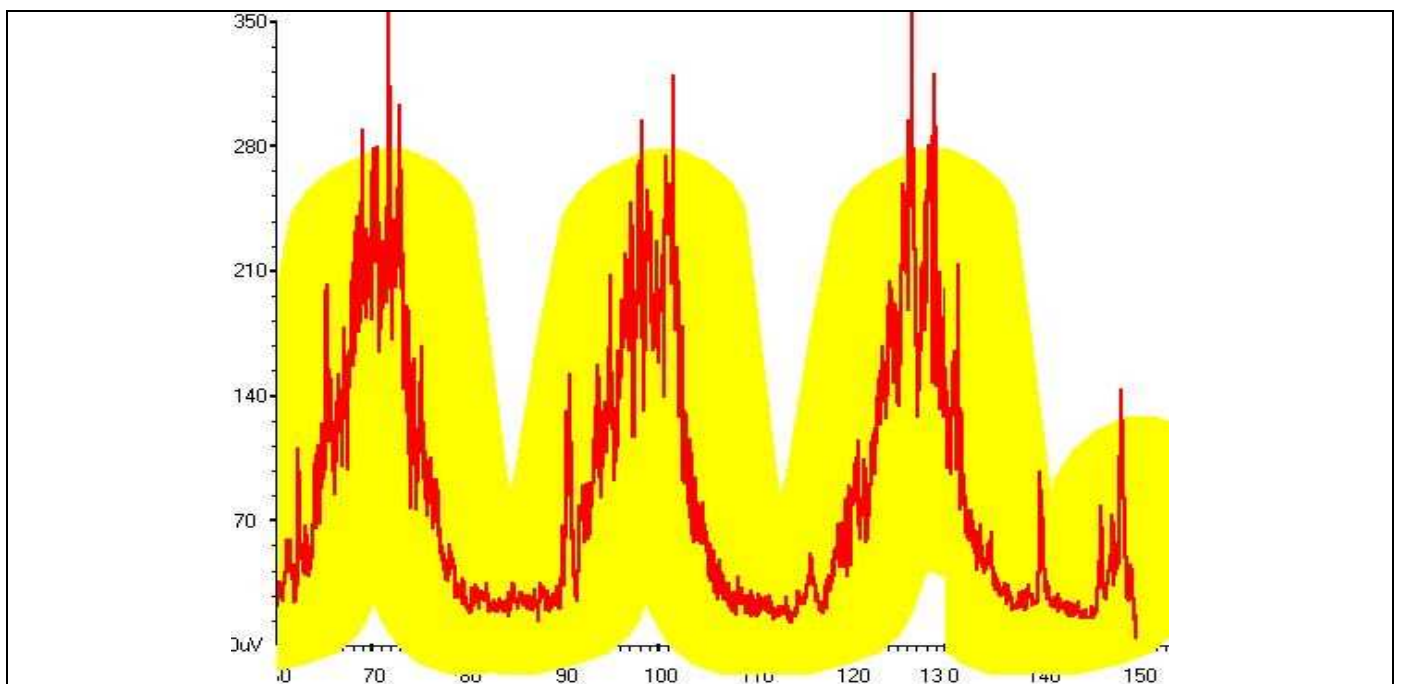
In standing with feet a comfortable distance apart. Tense leg muscles and bend knees slowly whilst maintaining the contraction. Once the required degree of flexion has been reached return slowly to the upright position whilst still maintaining the contraction. Repeat x10.



EMG Graph of a healthy 52 year old male who regularly cycles and walks.



**EXERCISE 4:**



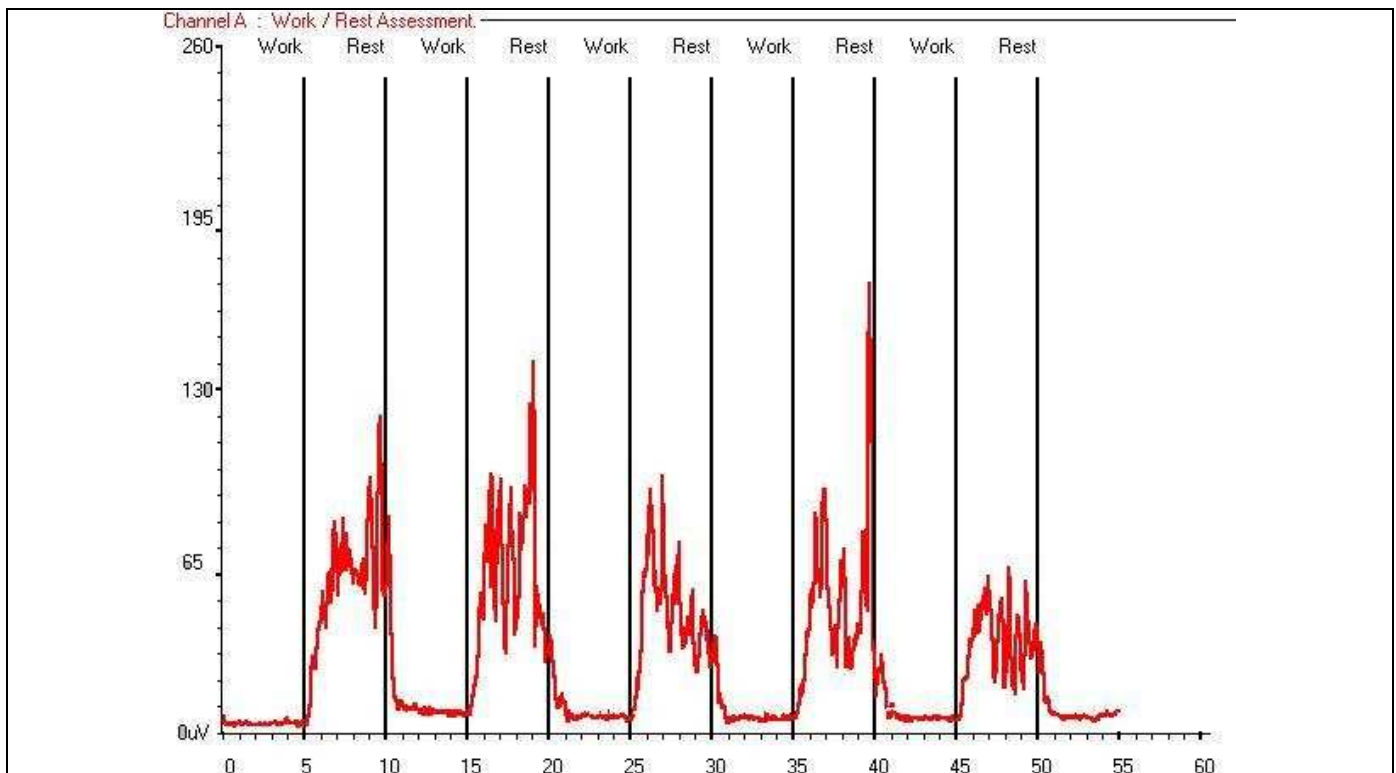
EMG Graph of a healthy 52 year old male who regularly cycles and walks.

## PATIENT WORK / REST ASSESSMENT

### USING THE NeuroTrac 5™

#### Initial Assessment:

By selecting the work/rest assessment mode on the NeuroTrac 5™ software the clinician can accurately review the patients progress. To initiate the medium to long - term progress report the user must follow a set procedure of setting 5 work/rest trials [repetitions] and 5 work/rest duration's of 2 to 10 seconds. Importantly, patients exercises completed at home or away from the clinic can be recorded on any of the NeuroTrac 5™ units and downloaded onto the PC to form part of the progress report. The report will highlight if the patient is actually completing and performing the exercises effectively. Also the progress report will show if the home and the exercises carried out under supervision are compatible.



Initial EMG Assessment of Person with Patellofemoral pain. (Trial Assessment)

### Patient Progress Report

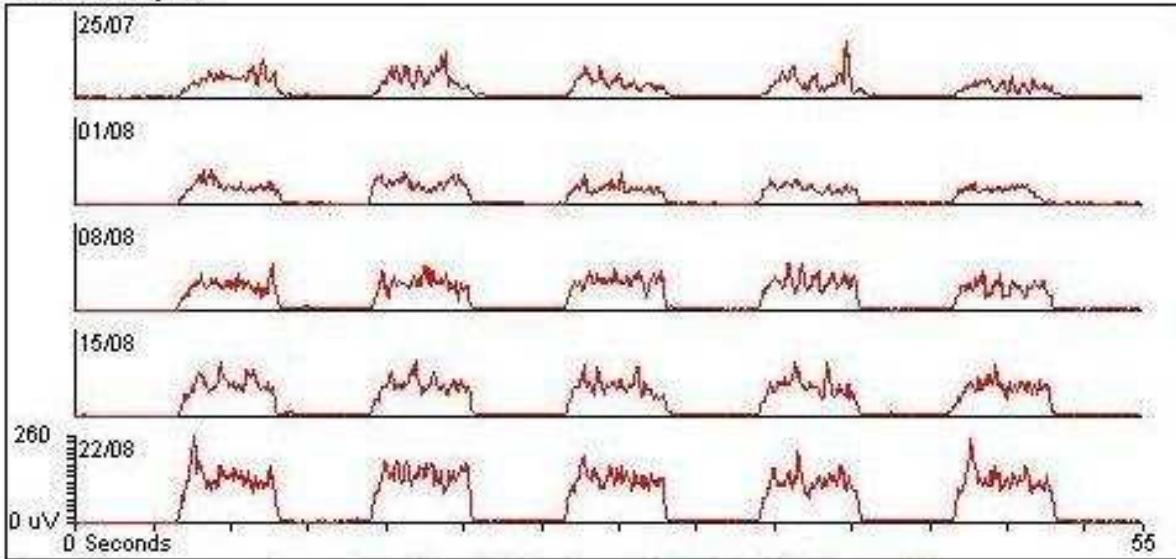


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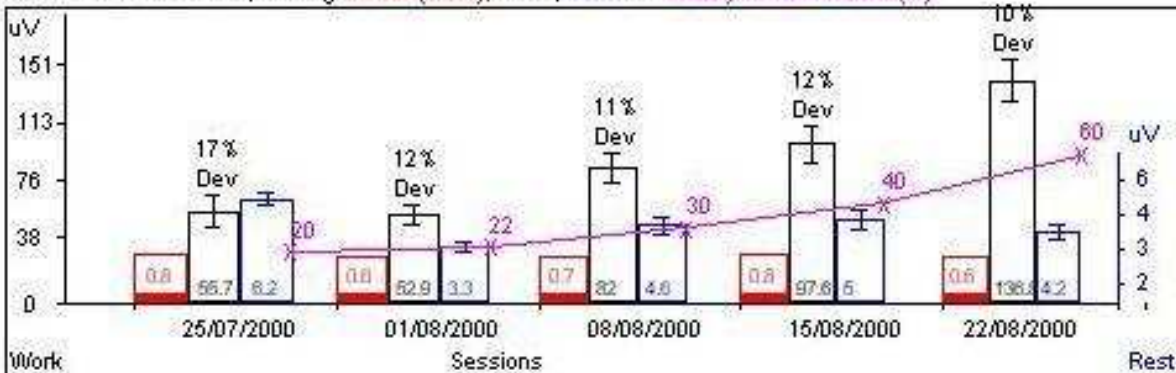
PatID 2: Patient Name: James Oliver: Condition:- Patella femoral Pain

Selected Session Dates:- 25 / 07 / 2000 to 22 / 08 / 2000

Channel A Progress



Channel A Assessment; Average Onset (Secs), Work, Rest with Quality of Life Factor (%).



Channel A Home Compliance.

Comments and Conclusions.

EMG Progress Report after 4 weeks of completed exercises. (Trial Report)

## Success of Treatment.

Most relief for PFP has traditionally been short lived, Deveraux & Lachmann (1984), confirmed this in a review paper when they found only a 30% success rate at 13 month, follow up. More recently, Almekinders and Almekinders (1994), in a review of outcome, in the treatment of chronic overuse sports injuries found that PFP had a significantly worse outcome than any other injury.

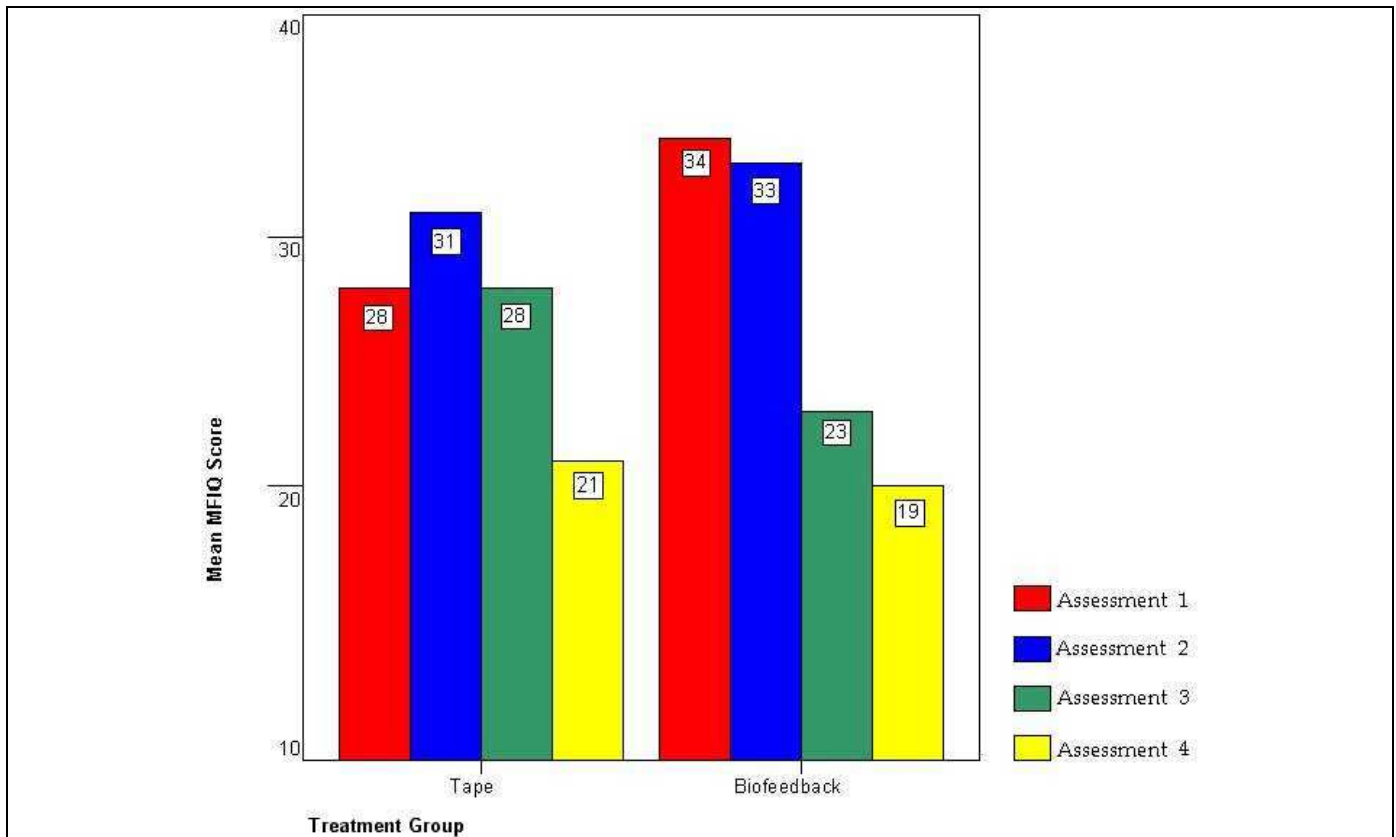
In a 5.7 year retrospective study of 250 athletes with patellofemoral pain Blond & Hansen (1998), report 68 (27%) were pain free and 95 (38%) had decreased pain, 64 (25%) had remained the same and 23 (9%) had increased pain. Patients were treated by a knee brace and home instruction in vastus medialis exercises. Interestingly more than twice as many men became pain free compared to women.

In contrast McConnell (1986), reports that after treatment using a stretching, patellar taping and VMO exercise approach 83% of patients were pain free, with a further 8.5% having decreased pain giving a total of 92% of patients responding favorably. Long term follow up at 12 months demonstrated that all patients reviewed remained pain free. Gerrard (1989), using the McConnell approach reports that 86.2% of patients required 5 treatments or less. 90.5% were pain free within 7 sessions. The need for greater than 7 treatment sessions was regarded as a failure. A combination of the good and excellent categories at 12 month follow up gave a 95% success rate with 86.7% of patients having returned to normal activity.

In Selfe, Gillard and Marshall's (1996), study of 41 NHS Orthopedic patients, using a similar approach the maximum number of treatment sessions any individual received was 8 with the average number being 4. Of the 32 patients completing treatment only 5 did not show any clinically significant improvement, this represents a success rate of, 81.5%.

Recent unpublished research (Selfe et al) suggests that single channel biofeedback used over the vastus medialis may produce better short-term results than patellar taping. Using a newly designed and validated outcome measure, the Modified Functional Index Questionnaire (MFIQ) (Figure 5), it was found that during the active treatment period of seven weeks, a group of patients (n = 31) using Biofeedback demonstrated a marked improvement in scores from 33 to 23 (figure 4).

**Figure 4** Histogram showing changes in MFIQ scores during a clinical trial, where assessments 1 & 2 were pre-treatment, assessment 3 was immediately post-treatment and assessment 4 was at three month follow up.



Although the taping group (n = 46) also demonstrated improvement the changes in score were not as great from 3 to 28. However by the end of a three month follow up period the differences between the two groups had evened out, Selfe et al (manuscript with reviewers).

## Conclusion.

There is still considerable controversy over the causes of pain and what the optimum treatment approach may be for patients with PFP. The role of the VMO and the importance of the VMO: VL ratio remains in question. However recent evidence suggests that Biofeedback is an extremely effective tool, at least in the short term, to use as an adjunct to the rehabilitation of patellofemoral problems.

Figure 5:

## Modified Functional Index Questionnaire (MFIQ).

Please answer the following questions by putting a tick in the appropriate box or column.

**During the last 24 hours have you had any pain from your knee?**

Slight or Intermittent	Constant
------------------------	----------

**During the last 24 hours have you walked with a limp?**

<i>Slight or Intermittent</i>	<i>Constant</i>
-------------------------------	-----------------

	<i>Unable to do</i>	<i>Could with a problem</i>	<i>No Problem</i>	<i>Not appropriate</i>
Walk as far as 1 mile on flat ground.				
Climb up 2 flights of stairs.				
Walk down 2 flights of stairs.				
Drive for 1/2 hour.				
Squat.				
Kneel.				
Sit for 1/2 an hour with knees bent at 90 degrees.				
Run 100 yards.				

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