POST-MENISCECTOMY REHABILITATION

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SUMMARY

Removal of the semi-lunar cartilage/s (menisci) of the knee is a common surgical procedure. Surgeons recognize the importance of an exercise programme supervised by a physiotherapist, in order to obtain the best post-operative rehabilitation. However, the best method of post-operative rehabilitation has been a controversial issue. Controlled studies to determine the relative effectiveness of different treatment regimes are reviewed. Substantial research is being carried out to determine the physiological effects of surgical procedures, subsequent immobilization and different forms of exercise on the leg. These are discussed and considered in formulating the ideal *post-meniscectomy rehabilitation programme. The effects and importance of isokinetic exercise is emphasized.*

OPSOMMING

Verwydering van die semi-lunêre kraakbeen (menisci) van die knie is 'n algemene chirurgiese prosedure. Chirurge erken die belang van 'n oefenprogram onder toesig van 'n fisioterapeut vir die beste post-operatiewe rehabilitasie. Dog, die beste metode van post-operatiewe rehabilitasie bly betwisbaar. Gekontroleerde studies om die relatiewe effektiwiteit van verskillende behandelingsprogramme te bepaal, word beskryf. Heelwat navorsing word tans gedoen om die fisiologiese effekte van chirurgie, immobilisasie en verskillende vorms van oefening op die been te bepaal. Dit word bespreek en oorweeg in die formulering van die ideale *post-menisektomie rehabilitasie program. Die effekte en belang van isokinetiese oefening word beklemtoon.*

INTRODUCTION

The aim of a rehabilitation programme is to return the patient to full functional capacity in as short a time as possible. Clearly, functional demands differ from patient to patient and this must be considered when a rehabilitation programme is formulated. The physiological changes which occur after meniscectomy and the subsequent immobilization of the injured leg are reviewed. The physiological effects of the various types of exercise are considered and these are applied in the formulation of a post-meniscectomy rehabilitation programme.

PRE-OPERATIVE MANAGEMENT

For patients with chronic injuries, a pre-operative programme of exercises should be performed. Logic suggests that this should strengthen the leg prior to surgery (McAustland, 1943; Luck *et al.*, 1948; Wyn-Parry *et al.*, 1958), and should introduce the patient to the type of exercise he will be required to perform immediately after the operation (Meekison, 1944; Yocum *et al.* 1978). It should be noted, however, that no controlled studies have been performed to determine whether or not pre-surgical conditioning is of any value.

POST-OPERATIVE CARE

Immediately (first hours) after surgery

Exercise rehabilitation should start soon after the operation, possibly even in the anaesthetic recovery room. Logically, this should help to minimise muscle atrophy and weakness which results from partial or total post-operative immobilization of the leg (McAustland, 1943; Luck *et al.*, 1948; Meekison, 1944; Wynn-Parry *et al.*, 1958). This has not yet been proven. Tourniquet-induced ischaemic damage to nerves and muscle may prevent effective voluntary movement immediately after surgery (Weingarden *et al.*, 1979). This part of the exercise programme may therefore be of limited value and is a possible area for further investigation.

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Subsequent days after surgery.

There have been two traditional methods of early management of patients who have had meniscectomies. In the first treatment regime (I) a compression bandage of the Robert Jones type is applied from mid-thigh to below the knee soon after the operation, and the patient is confined to bed for about ten days, after which his stitches are removed. The patient exercises by first performing static contractions of the quadriceps femoris muscles and later, straight leg raises are added. Knee flexion is attempted when it is performed within the limits of pain experienced by the patient. The patient is allowed to walk, first taking partial weight on the injured leg with the aid of crutches, and progressing to full weight bearing by about two to three weeks.

In the second treatment regime (II), an ankle to groin plaster cast is applied to the leg over a compression bandage. The cast is either applied immediately after the operation or shortly thereafter. The patient is allowed out of bed and walking with the aid of crutches within days of the operation. He may bear full weight on the operated leg as soon as pain permits.

A number of controlled studies have been performed to determine the relative effectiveness of the two different treatment regimes (Nelson, 1968; Rosborough, 1979; Gough, 1975; Leonard, 1975). Others have reported results obtained when using one or other of the regimes (Smillie, 1963; Dutchie and McLoed, 1943; Wynn-Parry *et al.*, 1958; Terhurne *et al.*, 1943; Lantzounis, 1931). The results of these are summarized in Table I.

The results in this table suggest that patients treated with regime II appear to have fewer days off work and fewer post-operative complications than do patients treated with regime I, although in some studies the differences are not marked.

The results of these studies are based purely on subjective observations. The degree of function that the patient has before returning to work may vary greatly between individuals. Their motivation to return to work may likewise be different. Pain perception and post-operative complications may also be viewed as being largely subjective. Therefore, the results are not completely valid parameters on which to base a scientific comparison of the respective treatment regimes. A more effective method of evaluating the return of muscle strength after surgery would be to

Table 1.

Author	Type of patient	Regime followed I	Regime followed II	No. of days off work	Post-operative complications I	Post-operative complications II
Smillie (1963)	Service & heavy	X	—	90	—	—
Dutchie & McLoed (1943)	Army	X	—	82	—	—
Wynn-Parry *et al.* (1958)	Air Force	X	—	62	—	—
Terhune *et al.* (1943)	All occupations	—	X	50	—	—
Lantzounis (1931)	All occupations	combination		38	—	—
Nelson (1968)	All occupations	X		43,5	—	—
			X	42	—	—
Gough (1975)	All occupations	X		52	—	—
			X	45	—	—
Leonard (1975)	All occupations	X		53,5	23,4%	15,2%
			X	51		
Rosborough (1970)	Not stated	X		II was less than I — value not given	23%	10%
			X			

measure the strength of the leg muscles during isokinetic contraction throughout the full range of knee movement at different contraction velocities.

The more vigorous approach of putting the operated leg in a plaster cast (regime II) seems to yield slightly better treatment results than the more conservative treatment (Regime I). Additional **advantages** of placing the operated leg in a plaster cast immediately after surgery are:

- Protection of the operation site from damage due to movement of the knee/leg.
- When considering the limited availability of space and staff in hospitals and the high costs of keeping a patient in hospital, it makes good sense to discharge the patient in the quickest possible time (Gough, 1975). This is best achieved by placing the operated leg in a long leg plaster cast and getting the patient up and walking as soon as possible.

Possible disadvantages are:

- Joint and muscle changes. Although there are definite changes in a joint and its surrounding structures when the joint is immobilized, all soft tissue changes in rabbit limbs are reversible if the limb is not immobilized for more than thirty days (McDonough, 1981). Similarly, in spite of the long leg plaster being carefully applied, there will still be a certain amount of movement of the leg within the plaster cast (Krackow and Vetter, 1981). Therefore, to put a leg into a long leg plaster cast (ankle to groin) for 10 to 14 days should not cause any lasting or irreversible changes to the knee joint or leg muscles (Eriksson, 1981).

SUBSEQUENT POST-OPERATIVE TREATMENT

Until recently, exercise rehabilitation programmes for this stage of treatment have emphasized strength training for the injured leg to the exclusion of all else. It is now apparent that equal, if not more attention must be given to

- the speed at which the exercises are performed, and
- the endurance training of the muscles. (Campbell and Glenn, 1979).

Thus, although knee function may appear to be "normal" in that after a strength-training programme the patient is able to lift the same weight with operated and non-operated legs, the operated leg may in fact **not** yet be "normal" in other respects. It may, for example, be weak at higher or lower contraction velocities and it may have reduced endurance capacity. Either or both of these deficiencies are likely to increase the chances of re-injury.

The principles of treatment are:

- A pre-operative strengthening programme of exercises should be given.
- Exercise of the injured leg is started as soon after the operation as possible.
- The leg is placed in a plaster cast until the stitches are removed. The patient can bear full weight on the operated leg when pain permits.
- Knee flexion exercises are commenced as soon as the plaster cast is removed.
- Exercise training must emphasize the development of both muscle strength and endurance.

THE NATURE OF THE DECREASED MUSCLE STRENGTH AFTER LIMB IMMOBILIZATION

There is good evidence that muscle strength is decreased after surgery (Eriksson, 1981; Yocum *et al.*, 1978). There are three possible reasons for this:

Muscle fibre atrophy

Muscle fibre atrophy becomes apparent shortly after the onset of limb immobilization, having been found immediately (Campbell and Glenn, 1979) or within the first week (Eriksson, 1981) after surgery.

Change in fibre composition of the muscle

Eriksson (1981) showed that there was a considerable decrease in Type 1 (slow twitch) leg muscle fibres after immobilization. Following a few months of intensive exercise rehabilitation the original proportion of muscle fibre types was achieved. It was also shown that immobilization of the leg in a position in which the muscle was under tension, caused less Type 1 muscle fibre atrophy than occurred when the muscle was immobilized in the relaxed position.

Neurological factors

Neurological factors play an important role in the increase in muscle strength after exercise rehabilitation and may be more important than hypertrophy of the muscle. The evidence for this has been supplied by Grimby (1982) who reported that when subjects are trained at low isokinetic (see following section) contraction velocities (60°/sec), increases in their peak torque production can be achieved without either changes in limb cross-sectional girth or muscle fibre area. But, after being trained at fast contraction velocities (300°/sec), the increased torques produced were associated with enlargement of Type II fibres.

This suggests that increased peak torque values achieved after training at high contraction velocities are due to hypertrophy of Type II muscle fibres, while at lower contractile velocities, neurological adaptations may be operative (Coyle *et al.*, 1981). These adaptations could include: the type of motor unit being recruited, the number of motor units being recruited and the frequency of motor unit activation (Sherman *et al.*, 1982). A more efficient summation of motor units would also cause the muscle to produce increased torque (Coyle *et al.*, 1981). Any or all these adaptations could explain the "cross-over effect" in which the strength of the contra-lateral, non-operated leg is increased after isokinetic training (see later). This form of strength increase also occurs in the absence of an increase in muscle size.

When a muscle contracts through its full range, it produces different torques at different muscle lengths of joint angles. The torque produced by a muscle **in vivo** is determined by two factors:

- the amount of overlap of the actin and myosin filaments (i.e. the sarcomere length) in accordance with the classic length-tension curve of muscle contraction (Fox and Mathews, 1981; Gowitzke and Milner, 1980).
- The change in mechanical advantage experienced by a muscle as the joint (and therefore limb) moves through its range of movement. **In vivo**, the muscles produce their peak torques at the joint angle that produces the optimal mechanical advantage.

During knee extension, maximal torque is produced at 56° knee flexion and this is true for all angular velocities of knee movement. Thus it is reasonable to conclude that weight lifting as the sole method of exercise rehabilitation is not acceptable, as the muscles will be working maximally during only those parts of its range of movement, at which the joint has low mechanical advantage. To overcome this limitation, isokinetic exercise is suggested.

THE CONCEPT OF ISOKINETIC TRAINING

What is isokinetic exercise?

During isokinetic exercise, movement is performed at a constant angular velocity. This type of exercise allows the resistance against which the muscle contracts to accommodate to the muscular force that is developed throughout the entire range of joint motion. It is therefore possible for the patient to maintain maximum force of muscle contraction throughout the **full** range of joint/muscle motion (Grimby, 1982; Sherman *et al.*, 1982). Thus, maximum strength training takes place through the entire range of joint/muscle motion.

The importance of contraction speed in muscle rehabilitation

The peak tension that a muscle is able to develop changes with the speed of muscle contraction, there being a fall in the peak torque produced as the speed of the contraction increases. (Coyle *et al.*, 1979; Fox and Mathews, 1981; Westers, 1982; Sherman *et al.*, 1982). Thus there is a 40% fall in the torque produced as the angular velocity is increased from 30 to 180 per second (Grimby, 1982). The fall in the maximum torque has a similar pattern in men and women of all ages.

However, it has been shown that muscles with a high percentage of Type II (fast twitch) fibres show less reduction in the maximum torque developed at increasing contraction velocities, than do muscles with a lower percentage of Type II fibres (McArdle *et al.*, 1981; Fox and Mathews, 1981; Grimby, 1982). This indicates the importance of Type II fibres in the development of force at higher contraction speeds. When exercise is performed at low contraction velocities (30% of maximum voluntary contraction (M.V.C.)), glycogen depletion is found mainly in Type I (slow twitch) muscle fibres, while at 50% M.V.C., the depletion is mainly in Type II fibres (Grimby, 1982).

Thus it may be deduced that training a muscle at different angular velocities during a rehabilitation programme will affect different muscle fibre types, so that the training velocity must be specific to the velocity achieved during the particular activity or sport in which the subject participates. Most functional activities employ muscle contraction speeds in excess of 240 degrees per second (°/sec.) (Smith and Melton, 1981). For example, during the last 12° of the swing phase of the gait cycle, the quadriceps muscles contract and extend the knee at 233°/sec. (Wyatt and Edwards, 1981). Thus, high contraction velocities should be used in the rehabilitation programme before the person attempts functional activities.

A second reason for the use of fast contraction speeds during rehabilitation is that at high contraction speeds the compression force at the joint is less than at lower contraction speeds. This is due to the lower force that the muscles can produce at the high contraction velocities (Grimby, 1982). After meniscectomy, it would be of benefit to limit the compression forces acting on the knee joint as these may damage the articular cartilage. Thus, high contraction velocities should be used in the early stages of the rehabilitation programme (see isokinetic programme progression).

The effects of training at different contractile velocities

Costill *et al.* (1979) reported that muscles trained at an angular velocity of 180°/sec., produced increased peak torques when contracting at 180°/sec. or at slower speeds, but not at higher angular velocities. Similar findings have been made by Coyle *et al.*, (1981) who used contraction velocities of 60 and 300°/sec. The group trained at 60°/sec. showed improvements in peak torque at 60°/sec. and at 0°/sec. (isometric contractions), while the group trained at 300°/sec. improved muscle peak torques at 0°, 60° and 300°/sec. However, the greatest increase in the peak torque occurred at the specific angular velocity at which the muscles were trained. Similarly, Sherman *et al.* (1982) trained athletes, who had undergone meniscectomies, at high velocities. However, when the strength of the operated leg had fully recovered at high contraction velocities, there were still strength deficits of up to 20% during lower speed isokinetic contractions. Thus, the leg must be treated at slow and fast contraction velocities to ensure that it has regained its full strength.

THE EFFECTS OF ENDURANCE TRAINING

Re-injury of a limb may result from the premature fatiguing of muscles that have had insufficient endurance training after surgery. Costill *et al.* (1977) compared a group of patients who had undergone meniscectomies and did progressive strength training, with a similar group who supplemented their strength training programme with 20 to 30 minutes' one-legged cycling daily, with the operated leg. They found that succinate dehydrogenase (S.D.H.) activity in the operated leg, which had decreased after the leg had been immobilized in a plaster cast, had not returned to control levels when only strength training was performed. However, the patients that performed both strength and endurance training, had higher S.D.H. activity in the operated leg muscles than in the non-operated legs.

In summary, the studies reviewed above indicate that exercise training of a limb must involve a complete rehabilitation programme which includes:

- isokinetic training at a full range of muscle contraction velocities. Only in this way will all muscle fibres (Type I and Type II fibres) be strengthened.
- endurance training.

Unless the muscles have regained their full strength and endurance, the patient is **not** ready to resume his normal sporting or daily activities due to risk of re-injury.

THE REHABILITATION PROGRAMME

The following is an example of an *ideal* rehabilitation programme for a patient who has undergone a meniscectomy. It takes into account the aspects of muscle physiology which have been outlined. The programme requires the use of isokinetic exercising apparatus. In addition, the patient will require a substantial amount of supervision in order to carry out the entire rehabilitation programme. The physiotherapist will not always be in a position to provide a complete programme due to the unavailability of some apparatus and/or supervision time. Therefore, improvisation must be made where necessary.

Pre-operative programme

Aims

- To strengthen the muscles around the knee.
- To familiarize the patient with the post-operative exercises.

Exercises

- Static/isometric quadriceps contractions. These are best done with the foot in dorsiflexion (Gough and Ladley, 1971).
- Straight leg raising (S.L.R.) in supine, i.e. hip flexion.
- S.L.R. in prone, i.e. hip extension.
- S.L.R. in side-lying, i.e. hip abduction.
- Resisted knee flexion and extension, performed in prone and using the unaffected leg to resist the injured leg.
- Knee flexion and extension, using isokinetic apparatus (only in cases where the injury is chronic).

Proviso

Exercises may cause excessive pain and/or further damage to the patient's knee.

Post-operative programme

Stage I

Immediately post-operative until the removal of the plaster cast.

In the anaesthetic recovery room
Aims

- To maintain muscle strength.
- To prevent muscle atrophy.
- To aid haemodynamic function.

Exercises

- Static/isometric quadriceps contractions.
- Active ankle and foot movements.
- Attempted S.L.R. in supine.

Proviso

It may not be possible to perform these exercises due to neural damage during the operation, e.g. tourniquet-induced ischaemia.

In the ward
Aims

- To maintain/increase muscle strength.
- To prevent muscle atrophy.

Principles

- The exercises are performed hourly, initially under supervision and later without supervision.
- Each exercise is performed until the muscles fatigue.
- The patient may start to walk, with the aid of crutches, as soon as he wishes. The physiotherapist must ensure that the patient is able to maintain his balance before allowing him to walk without supervision. The patient may toe-touch at first and progressively take more weight on the operated leg until he bears full weight on it.
- The patient should exercise the rest of his body in order to maintain general fitness.

Exercises

- Isometric quadriceps contractions. If there is evidence of strain on the operation site, quadriceps contractions and S.L.R.'s can be attempted with the hip held in slight internal rotation (Yocum *et al.*, 1979).
- Attempted S.L.R. in supine.
- Attempted S.L.R. in prone.
- Attempted S.L.R. in side-lying.

Stage II

The period after the plaster cast is removed
Aims

- To strengthen the leg muscles fully.
- To train the leg muscle endurance.
- To achieve full range knee movement.

Principles

- The exercises are performed 3 - 7 times per week in a suitably equipped gymnasium.
- The patient may at first walk with crutches, progressing to unaided gait when strength, pain and confidence allows.
- S.L.R. is performed with light weights (e.g. 1 kg) placed on the foot. Progression is made by increasing the mass of weights lifted. When 10 kg can be lifted 10 times without a rest, isokinetic training may be started (Sherman *et al.*, 1981).
- Knee flexion exercises are started immediately after the cast is removed.
- If the knee joint becomes painful or oedematous, treat by appropriate physiotherapeutic techniques.
- Isokinetic exercise procedure: (based on the procedure described by Sherman *et al.*, 1981).
  - — Begin knee flexion and extension exercises at 60°/sec. and progress to 120, 180, 240 and 300°/sec.
  - — Higher angular velocity exercises are performed as soon as a torque can be developed at that higher speed (i.e. weak muscles cannot develop torque

when contracting at high velocities). This will help to minimise possible joint damage caused by the high joint compression forces associated with high tension, low velocity muscle action.
— Exercising at a particular angular velocity is stopped when the torque generated is 50% of the initial torque during that particular set.
— Two sets of exercise until fatigue are performed at each training velocity with a 3 - 5 minute rest between sets.

- Cycling exercises may be started when the knee has about 20° flexion. At first, the patient will not have enough flexibility to cycle and will simply move the pedal backward and forward through a partial revolution. Flexibility will improve until a sufficient range of motion allows cycling. The stationary bicycle will allow the patient to do low intensity work for prolonged periods and therefore improve muscular endurance fitness of the leg.

Exercises

- S.L.R. with weight/s on the foot.
- Knee flexion exercises. Started with a pillow under the knee and progress by lowering the manually supported leg, while the thigh is fully supported on a chair or plinth.
- One-legged cycling (15 - 20 mins.), progressing to using two legs (30 - 40 mins.).
- Isokinetic exercises.
- Functional exercises. Start with walking and later include walking on inclines, balance board training, stop-start jogging and figure-of-8 running. Special attention must be given to the activities which the person will later be required to perform during sport or functional activity. Functional demands will differ between individuals.

Return to sport

The patient should undergo a vigorous *fitness test* before he may return to competitive sport. The test should include the type of exercise and physical stresses that are likely to be placed on the knee during the particular sport in which the patient wishes to compete. If the patient has pain and/or swelling in or around the knee following the test, he is not ready to return to competitive sport and must undergo further rehabilitation before being re-tested.

CONCLUSION

Knee meniscectomy is one of the most commonly performed operations. There has been a general lack of awareness of the need for rehabilitation with regard to endurance and strength training at a full range of angular velocities of knee movement. There is a need for rehabilitation centres which have adequate facilities which includes isokinetic exercising equipment.

The physiotherapist conducting the rehabilitation programme must have a good knowledge of the sport or activities that the patient will be required to perform following his return to *normal* activities. This ensures that the patient is trained and later tested in the specific activities he will later be performing. This may help to prevent re-injury to the leg.

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