

THE EFFECTS OF MENISECTOMY

A FOLLOW-UP STUDY OF THE EFFECTS OF MENISECTOMY ON LOWER LIMB MUSCLE STRENGTH, AND ON KNEE JOINT FUNCTION.

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SUMMARY

The object of this study was to determine the long term results of uncomplicated menisectomies in 16 patients who were at least 8 months post-operative. The average age of the patients was 25 years and all had right dominant legs. Seven of the subjects had undergone right knee surgery, and the remaining eight left knee surgery.

Questionnaires were answered to determine the patients' current symptoms and functional ability. Fifteen patients attended a physical examination to assess quadriceps and hamstring muscle strength. The findings were compared to a control group of subjects who had not undergone knee surgery. This study shows that:

- (i) Sixty percent of the patients had some symptoms such as stiffness, swelling, pain or discomfort, locking, weakness and instability. Seventy-five percent of the patients had some functional limitations during for example squatting, kneeling, climbing stairs, walking on rough ground etc, and half of these surgical patients had some pain and discomfort, as well as difficulty in squatting and kneeling.
- (ii) Eight months after surgery, the patients had still not regained full muscle strength despite having undergone *normal* rehabilitation procedures. Isokinetic muscle testing showed a decrease in quadriceps muscle strength in the right-operated leg, the left-operated leg and the right unoperated leg. There was also an increase in right hamstring muscle strength in the right-operated leg.

These findings suggest that even uncomplicated menisectomy is not a trivial procedure and that current practices in muscle rehabilitation following menisectomy are not adequate. There should be routine procedures whereby all patients can receive appropriate and adequate muscle rehabilitation after knee surgery.

OPSOMMING

Die doel van hierdie studie was om die langtermyn resultate van ongekompliseerde menisektomies te bepaal in 16 pasiënte wat ten minste agt maande post-operatief was. Die gemiddelde ouderdom van hierdie pasiënte was 25 jaar en almal het regterbeen dominansie vertoon. Sewe van hulle het operasies op hulle regter knieë ondergaan, en die oorblywende agt op hulle linker knieë.

Vraelyste is beantwoord om die pasiënte se huidige simptome en funksionele vermoë vas te stel. Vyftien het 'n fisiese ondersoek ondergaan om die krag van hulle agterdyspiere en quadricepsspiere vas te stel. Die bevindings is vergelyk met 'n kontrole groep van gevalle wat nie knie operasies ondergaan het nie. Hierdie bevindings toon aan dat:-

- (i) Sestig persent van die pasiënte het simptome vertoon soos styfheid, swelling, pyn of ongemak, swakheid en onstabieleit. Vyf en sewentig persent het 'n mate van funksionele beperkings ondervind gedurende byvoorbeeld hurk, kniel, trapklim, stap oor ongelyke grond ens., en helfte van hierdie chirurgiese pasiënte het 'n mate van pyn en ongemak ondervind sowel as probleme met hurk en kniel.
- (ii) Agt maande na hulle operasies het die pasiënte nog steeds nie algehele spierkrag herwin nie tenspyte daarvan dat hulle *normale* rehabilitasie prosedure ondergaan het. Isokinetiese spiertoetsing het 'n vermindering vertoon van quadricepsspier sterkte in die regter ge-opereerde been, die linker ge-opereerde been en die regter onge-opereerde been. Daar was ook 'n toename van sterkte in die regter agterdyspiere in die regter ge-opereerde been.

Hierdie bevindinge doen aan die hand dat selfs ongekompliseerde menisektomie nie 'n kleinigheid is nie en dat huidige praktyke in spier rehabilitasie wat volg op menisektomie nie toereikend is nie. Daar behoort roetine prosedures te wees waar volgens alle pasiënte toepaslike en doeltreffende spier rehabilitasie na knie chirurgie kan ontvang.

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INTRODUCTION

Any sporting injury to the knee that requires surgery is a potentially serious injury, because it may leave the sportsman with persistent knee problems such as instability,

pain on weight-bearing and swelling, in spite of early diagnosis and appropriate treatment.¹

Meniscectomy is one of the most common procedures performed by orthopaedic surgeons, and between 28-69% of meniscus injuries are reported to have been sustained in sport.^{2,3} There is much controversy over the results of surgery, so that the orthopaedic literature is replete with contradictory statements regarding the long-term results in patients who have undergone meniscectomies. For example Henderson⁴ and Wynn Parry et al.³ have reported that 75% or more of their patients had relatively normal knees when evaluated up to eight years after surgery, whereas Huckell⁵ reported that only 26% of their patients had relatively normal knees when studied sixteen years after meniscectomy.

A recent study on the longterm results of meniscectomy in athletes⁶, found that 27% had stopped or restricted their athletic activities as a result of surgery. Common complaints included swelling, instability, pain, locking etc. These complaints started immediately after surgery in 79% of the patients, the major complaints being a feeling of instability and pain on weight bearing. In a similar study Yocum et al.⁷ found that only 50% of their subjects felt that they had returned to a satisfactory level of competition, 1½ years after meniscectomy.

In this paper, the subjective and clinical end-results in a group of subjects who had undergone uncomplicated meniscectomies were analyzed in order to evaluate:-

- (i) The effects of meniscectomy in limiting sports participation and knee function (in squatting, kneeling, climbing stairs etc.), as well as the presence of symptoms (such as stiffness, swelling, pain, locking etc.).
- (ii) Lower limb muscle strength during isometric, slow speed and fast speed isokinetic muscle contractions.

MATERIALS AND METHODS

Subjects:

Questionnaires were sent to patients who had had meniscectomy performed either at Groote Schuur Hospital or by a private orthopaedic surgeon. All patients were at least eight months postoperative. Patients who had evidence of other injuries such as osteochondritis dissecans, loose bodies, degenerative arthritis, chondromalacia patellae or torn ligaments at the time of operation were excluded. The questionnaire was designed to determine the patient's current symptoms, the level of his recreational physical activity, and the presence of any disability related to his injured knee.

Of the twenty questionnaires sent, sixteen were completed and returned. One patient was omitted due to the presence of degenerative arthritis prior to surgery. Fifteen of these patients were evaluated at the S.A.B. Sports Injury Clinic at the University of Cape Town. Two of the subjects were female and thirteen were male, and their ages ranged between twenty-two and fifty-three years. Their ages at the time of operation ranged from seventeen to fifty years (average age twenty-five years). Eight of the subjects had undergone left knee surgery and the remaining seven had undergone right knee surgery. The time delay between the initial injury and surgery ranged from seven days to eleven years. In the latter subject, surgery was the result of a second injury.

ANALYSIS OF THE QUESTIONNAIRE DATA:

The patient's current symptoms and disability related to his knee were graded from the questionnaire, according to the following scale:

1. EXCELLENT : The patient had no symptoms and no disability related to his knee.
2. GOOD : The patient had any of the following symptoms but only once a month: stiffness, swelling, pain, weakness and instability. There was some limitation in the following activities: squatting, kneeling, climbing stairs, walking on rough ground and changing direction whilst running/walking.
3. FAIR : The patient had the above symptoms not more than once a week and had marked disability in the above activities.
4. POOR : The patient had constant symptoms and was unable to perform the above activities.

PHYSICAL EXAMINATION

Each patient was examined in the following manner:

- Thigh circumference measured with a tape measure at three different positions—6 cm, 12 cm, and 18 cm above the apex of the patellae.
- Range of Joint movement measured with a goniometer.
- Muscle strength. The orthotron II isokinetic dynamometer was used to measure the torque output of the quadriceps and hamstring muscle groups (in footpounds).

Maximal reciprocal contractions of the quadriceps and hamstring muscles for both extremities were performed at test speeds of 0°/s, 60°/s, and 300°/s. Each subject was positioned on the Orthotron with his or her back fully supported with hips in 75-80 degrees of flexion. The thigh was stabilized with a Velcro strap and the subject's knee was concentrically aligned with the dynamometer input shaft. The tibial pad was placed on the distal third of the tibia and held firmly in place with another Velcro strap. Each subject then performed a series of 10 submaximal muscle contractions at 120°/s in order to 'warm up' and to become accustomed to the equipment. A rest period of ninety seconds followed before the actual testing commenced.

Two testing sequences were used to diminish the variability that might have been caused by either learning or fatigue. Half of the subjects were tested in a 'slow' sequence using 3 sets of 10 isokinetic contractions in sequence at the following speeds—60°/s, 300°/s, 0°/s. The remaining half were tested in a 'fast' sequence using the reverse order—300°/s, 60°/s, 0°/s. A ninety second rest period was allowed between each set. Isokinetic extension power (isokinetic contraction speed equals 0°/s) was recorded with the knee in 65 degrees flexion, and isometric flexion with the knee in 45 degrees flexion. Only the peak torques generated at the various velocities were recorded.

A control group of eleven subjects aged between twenty and twenty-five years was also tested in an identical manner.

These data were analysed to determine:

1. The difference in knee torques during both flexion and extension, in the dominant and non-dominant legs of the operated subjects. Lower extremity dominance was defined as the foot the subject used to kick a football. (Only right dominant subjects participated in this study).
2. The difference in knee torques during both flexion and extension in the dominant and non-dominant legs of the control subjects.
3. The percentage differences in knee torques during flexion and extension in the dominant and non-dominant legs of

the operated subjects were compared with those of the control subjects.

A. RESULTS OF QUESTIONNAIRE

1. Cause of Injury

82% of the patients sustained meniscal injury during sporting activity. The others sustained their injuries during normal every day activity.

2. Presence of Rehabilitation

All subjects had either undergone physiotherapy or had designed their own exercise programmes, but the intensity and nature of such programmes could not be accurately assessed.

3. Subjective and Functional Results after Meniscectomy

Table 1 details the incidence and severity of reported symptoms in the 16 subjects. Half of the patients had some pain and discomfort, and 38% of the patients had stiffness and weakness of their knee, which was present at least once every month.

The functional results following meniscectomy (Table 2) indicate that the vast majority of the subjects had some difficulty in kneeling and squatting following meniscectomy. Climbing stairs, walking on rough ground, and changing direction whilst running caused problems in fewer subjects.

4. Influence of meniscectomy on sports participation:

Ten of the sixteen patients who had undergone knee surgery said that their sporting activity had been altered following surgery. Three of the patients gave up contact sports due to the feeling of instability in the operated leg, and three patients were now playing less vigorous sports. Other alterations included reducing the time spent on sport, and not playing as much competitive sport.

B. RESULTS OF PHYSICAL EXAMINATION

Fifteen right-legged dominant subjects were examined. Seven of the subjects had undergone right knee surgery and eight, left knee surgery.

1. Thigh Circumference:

Ten of the subjects had a decrease, and five an increase in thigh circumference. It has been shown that concomitant with muscle atrophy after immobilization following surgery, there is an increase of subcutaneous tissue so that the measurement of limb circumference may not reveal the true degree of muscle atrophy.⁸

Thigh Circumference	Right operated knee (7)		Left operated knee (8)	
	Increase	Decrease	Increase	Decrease
Number of Subjects	2	5	3	5

2. Range of Joint Motion:

No significant difference was noted in range of joint movement between the operated and non-operated knees.

3. Muscle Strength:

The peak static (0°/s) and isokinetic torque values measured during knee flexion and extension at 300°/s and 60°/s for the right operated and left operated leg are given in Tables 3 and 4 below. The percentage by which the values for the right leg exceed those of the left leg are also included.

It should be noted that in the right-operated-leg-subjects, only the isometric strength of the right hamstrings was

Table 1

SUMMARY OF COMPLAINTS OF PATIENTS FOLLOWING MENISECTOMY

COMPLAINT	EXCELLENT (None)	GOOD (Monthly)	FAIR (Weekly)	POOR (Daily)
Stiffness	10 (63%)	3 (19%)	2 (13%)	1 (6%)
Swelling	11 (69%)	3 (19%)	1 (6%)	1 (6%)
Pain or discomfort	8 (50%)	5 (31%)	3 (19%)	0
Locking	14 (88%)	2 (13%)	0	0
Weakness	10 (63%)	3 (19%)	3 (19%)	0
Instability and giving way	12 (75%)	3 (19%)	0	1 (6%)

Table 2

SUMMARY OF LIMITATIONS OF ACTIVITIES OF PATIENTS FOLLOWING MENISECTOMY

ACTIVITY	EXCELLENT No difficulty.	GOOD Some difficulty.	FAIR Extreme difficulty.	POOR Inability to perform activity.
Squatting	8 (50%)	7 (44%)	1 (6%)	0
Kneeling	6 (38%)	8 (50%)	1 (6%)	1 (6%)
Climbing stairs	14 (88%)	2 (13%)	0	0
Walking on rough ground	14 (88%)	2 (13%)	0	0
Changing direction whilst running	11 (69%)	3 (19%)	2 (13%)	0

significantly greater than the left hamstrings (by 22%). The quadriceps in the right-operated-leg showed no significant increase in muscle strength when compared with the left leg. (Table 3).

Table 4 shows that maximal torque values during low speed and isometric quadriceps contraction were significantly lower in the left-operated limbs (compared with the right).

Control subjects show significantly greater peak torque values for the right dominant leg during isometric quadriceps contraction and high speed hamstring contractions. (Table 5) This indicates that leg dominance influences muscle strength so that leg dominance must be considered in any evaluation of the effects of surgery and rehabilitation of muscle strength. Furthermore, it is also of interest that the quadriceps produced a higher torque than did the hamstrings at each of the three test speeds, but the torque difference decreased as the test speed increased. This phenomenon is well documented.

In order to draw some conclusions about the influence leg dominance has on muscle strength after surgery, Figure 1 has been drawn. It shows the percentage difference in peak torque values between right and left legs during isometric and low speed quadriceps contractions, and isometric and high speed hamstring contraction. Only these data are presented as they were the only ones in which statistically significant differences were found. Data for control subjects, left operated legs and right operated legs are presented separately. The relevant findings are the following:

1. **During isometric quadriceps contraction:**

The right quadriceps of the control group produced a 25% greater torque than did that of the left leg. The subjects with left operated legs showed a 16% greater right quadriceps torque compared with the left leg, whereas the subjects with right knee operations had equal isometric quadriceps torque output on both sides.

These results therefore indicate that the right quadriceps of people with right leg dominance are

Table 3

PEAK TORQUE VALUES (FOOT POUNDS) AT THREE DIFFERENT ISOKINETIC CONTRACTION SPEEDS FOR RIGHT OPERATED LEGS.

Muscle group and contraction speed	Peak Torque		Percentage Difference Between Right and Left Sides (% R > L)	P Value (Students t-test)
	Right (operated)	Left Leg		
Isometric Quadriceps (0°/s)	201 ± 46	201 ± 42	0%	NS
High Speed Quadriceps (300°/s)	108 ± 46	110 ± 40	0%	NS
Low Speed Quadriceps (60°/s)	157 ± 50	167 ± 55	-6%	NS
Isometric Hamstrings (0°/s)	154 ± 28	120 ± 19	22%	0.001*
Highspeed Hamstrings (300°/s)	106 ± 45	93 ± 39	11%	NS
Low Speed Hamstrings (60°/s)	159 ± 32	142 ± 32	11%	NS

Mean values, standard error or the mean (S.D), percentage difference between right (operated) and left sides (% R > L), and significant levels between paired observations are given.

Isometric quadriceps contraction was performed at a joint angle of 65° of flexion, whereas isometric hamstring was performed at 45° of flexion.

Table 4

PEAK VALUES (FOOT POUNDS) AT 3 DIFFERENT ISOKINETIC CONTRACTION SPEEDS FOR LEFT OPERATED LEGS.

Muscle Group and Contraction Speed.	Peak Torque		Percentage Difference Between Right and Left Sides (% R > L)	P Value (Students t-test)
	Left (Operated)	Right		
Isometric Quadriceps (0°/s)	148 ± 37	170 ± 45	18%	<0.001*
Highspeed Quadriceps (300°/s)	83 ± 37	99 ± 47	16%	NS
Low speed Quadriceps (60°/s)	142 ± 49	165 ± 52	14%	<0.05*
Isometric Hamstrings (0°/s)	109 ± 41	116 ± 39	6%	NS
High Speed Hamstrings (300°/s)	114 ± 38	93 ± 44	-18%	NS
Low Speed Hamstrings (60°/s)	118 ± 34	130 ± 34	9%	NS

Mean values, standard error of the mean (S.D) percentage difference between right and left sides (% R > L), and significant levels between paired observations are given.

Isometric quadriceps contraction was performed at a joint angle of 65° of flexion, whereas isometric hamstring contraction was performed at 45° of flexion.

Table 5
PEAK VALUES (FOOT POUNDS) AT 3 DIFFERENT ISOKINETIC CONTRACTION SPEEDS FOR CONTROL SUBJECTS.

Muscle group and Contraction Speed	Peak torque		Percentage Difference Between Left and Right Sides (% R > L)	P Value (Students t test)
	Right Leg Mean	Left Leg Mean		
Isometric Quadriceps (0°/s)	175 ± 62	118 ± 32	25%	<0.05*
High Speed Quadriceps (300°/s)	192 ± 42	180 ± 34	6%	NS
Low Speed Quadriceps (60°/s)	218 ± 47	198 ± 48	9%	NS
Isometric Hamstrings (0°/s)	128 ± 34	120 ± 28	6%	NS
High Speed Hamstrings (300°/s)	151 ± 35	133 ± 24	13%	< 0.01 *
Low Speed Hamstrings (60°/s)	135 ± 28	125 ± 26	7%	NS

Mean values, standard error of the mean (S.D) percentage difference between right and left sides (% R > L), and significant levels between paired observations are given.

Isometric quadriceps contraction was performed at a joint angle of 65° of flexion, whereas isometric hamstring contraction was performed at 45° of flexion.

stronger than their left quadriceps, and that right knee surgery causes a decrease in right quadriceps strength, whereas left knee surgery causes a decrease in both left and right quadriceps strength. This suggests that causes other than that of the effects of surgery must play a role in promoting muscle weakness. A reduction in general physical activity after surgery could be one such factor.

2. During low speed quadriceps contraction:

The controls had a 9% greater torque output with the right leg than the left leg. The left operated leg subjects had a 14% greater right quadriceps strength, compared with the operated leg, and the right operated leg subjects, only a 6% greater right quadriceps torque than the unoperated leg. These results show that surgery causes a decrease in low speed quadriceps muscle strength on the side on which it was performed.

3. During isometric Hamstring contraction:

Subjects whose right knees had been operated on, had a 21% greater muscle strength in their right than their left hamstrings. In the control group, and the left-operated group, this difference was only 6%.

This result indicates an increase in right hamstring muscle strength following right knee surgery, which may be a compensatory result in order to promote right dominant leg stability.

4. During high speed hamstring contraction:

The subjects whose left legs had been operated on had an 18% greater muscle strength in their right Hamstrings than in their left legs, whereas in the controls this difference was only 12%.

This result suggests that left hamstring muscle strength may be reduced following left knee surgery.

of the tibia and femur are greatly increased in any activity causing an increase in weight bearing across the knee as in running, walking and jumping, but also in squatting and kneeling. The stresses across the joint are significantly increased after meniscectomy¹ for a given load transmitted across the joint. After meniscectomy, the amount of compressive deformation is approximately twice that measured in the intact joint. Therefore, the menisci serve the important function of reducing the compression of the articular cartilage and subchondral bone and meniscectomy would be expected to alter and load-bearing ability of the joint quite substantially.

Furthermore, menisci play a role in the stability of the knee, and the increased instability following knee surgery may be a contributing cause to the high incidence of new knee injuries after meniscectomy.⁶ In this study, half of the subjects experienced occasional pain and discomfort on normal activity, as well as difficulty in squatting and kneeling, and 62% had altered their sports participation in some way following meniscectomy. This serves to indicate the importance of the meniscus in the normal function of the knee joint.

Besides the effects that are a direct result of removal of the menisci, surgery causes muscle atrophy and muscle weakness^{10,8,6}. Ten of the subjects had a decrease in thigh circumference when evaluated more than eight months post-operatively, but five subjects had an increase. This result was not influenced by the side of the knee surgery, and showed no correlation with muscle strength. It should be noted that during the immobilization following surgery, there is an increase in subcutaneous fat tissue and this obscures muscle atrophy and could explain these apparently strange results⁸.

Previous workers have reported a decrease in muscle strength after knee surgery^{11,12} but they have not considered the importance of leg dominance. In our control group the right leg was stronger than the left leg, particularly during isometric quadriceps contraction, but in the test group (after meniscectomy) the following was found:

1. During isometric quadriceps contraction, quadriceps power in the right (unoperated leg) was significantly greater than that in the left (operated) leg. This suggests

DISCUSSION

The menisci in the knee are known to perform several important functions, in particular they act as load-transmitting and energy-absorbing structures inside the joint. The forces between the menisci and articular surfaces

that knee surgery causes a long term impairment in muscle strength. However, the relative isometric quadriceps strength of the right leg also decreased (in comparison to the left leg) following left knee surgery. This is unexpected, but may be due to a general decrease in the level of physical activity. Additional evidence for this is the finding that 62% of the patients in this study had altered their sports participation in some way following meniscectomy. Similar results have been found by other researchers. Sonne-Holm⁶ showed that 27% of his subjects stopped or restricted their sporting activities

after meniscectomy, and Yocum et al.⁷ found that only half of their subjects returned to their previous level of competition one-and-a-half years after knee surgery.

2. The quadriceps of the operated leg regardless of side showed a decrease in low speed torque when compared to findings in control subjects. There are a number of explanations for this: There may be long-term impairment of motor unit recruitment at maximal effort or impairment of contractile properties of the muscle following knee surgery and immobilization, or both⁹.

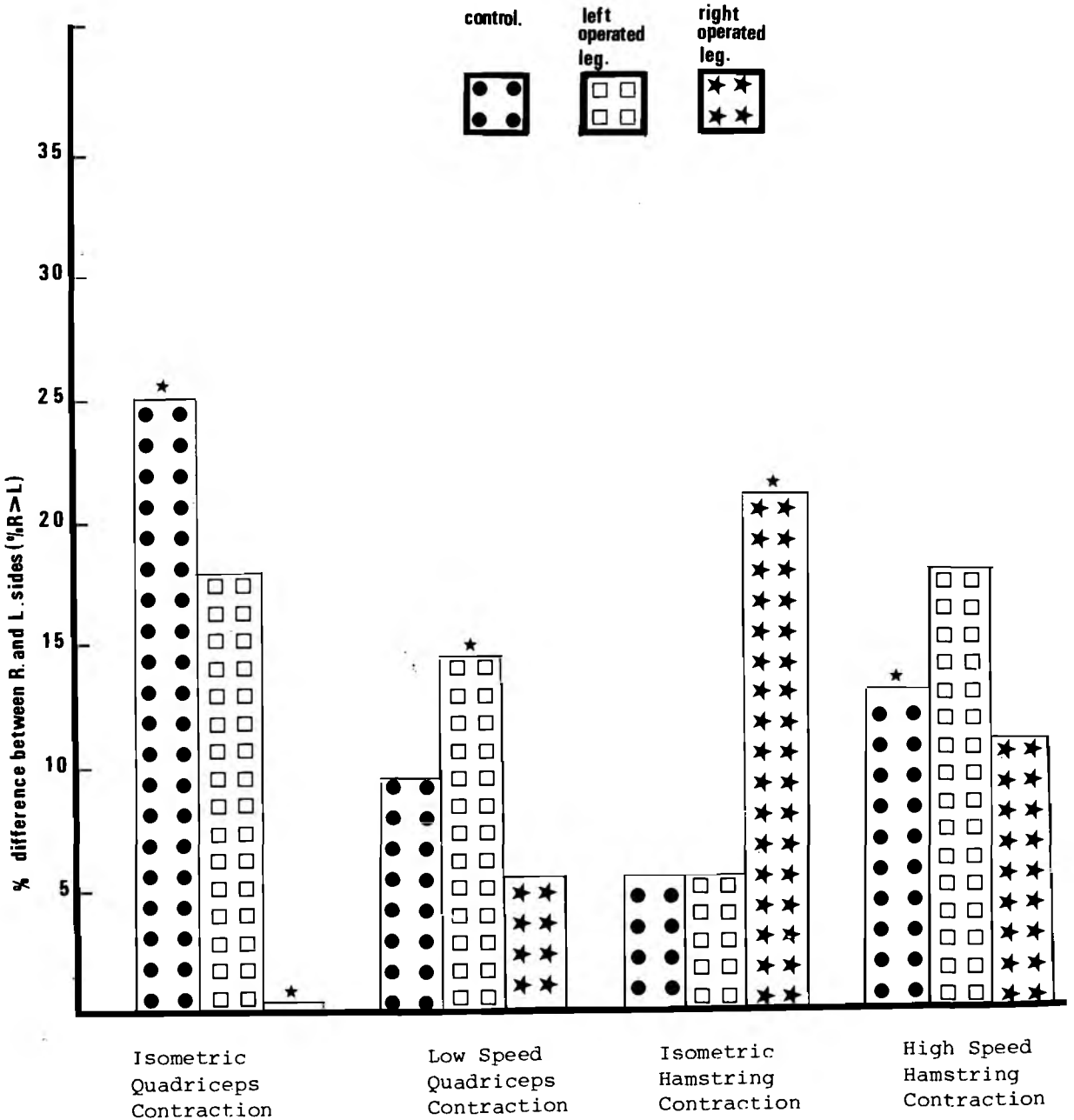


Fig. 1

(i) **Tourniquet-induced Muscle damage**

During isometric muscle contraction, the slow twitch fibres are recruited first, and as more tension is required, more fast twitch fibres are recruited¹. Studies using muscle biopsies have shown that after sports injuries and immobilization of the knee joint, it is mainly the type I fibres (slow twitch) that atrophy¹⁰. Haggmark et al.⁸ and Booth et al.¹³ have shown that this type I fibre atrophy occurs very rapidly after immobilization of the knee joint, within the first six hours to first week following immobilization. Besides atrophy, there might also be a change in fibre type composition, that is, a change in the relative proportion of type I and type II fibres. It was also found that the extensor muscles and the more tonic muscles with higher tension and higher percentage of type I fibres showed more pronounced signs of atrophy⁴. Thus the difference in isometric muscle strength could be due to selective atrophy of type I fibres^{10,8}.

(ii) **The effects of immobilization in the extended knee position**

It has been found that when lower limb immobilization is in a position where the muscle is on tension, there are no signs of atrophy.^{10,9} An explanation for this would be that the muscle spindles within the muscle relax when there is no tension and the impulses returning to the extrafusal muscle fibre via the monosynaptic reflex arc disappear, and the afferent impulses to the tonic type I fibres cease. The knee is immobilized in an almost straight position after surgery, relaxing the quadriceps muscle which could have contributed to the atrophy found in this study.

(iii) **Tourniquet-induced nerve damage**

A large percentage of surgery for sports injuries is performed under tourniquet to ensure a bloodless surgical field. Some authors suggest that tourniquet-induced ischaemia causes both muscle damage and damage to the peripheral nerves. Impaired nerve function measured electro-myographically has been reported in as many as 71% of patients¹¹ and involves the following nerves in the following sequence: The posterior tibial nerve which supplies the gastrocnemius muscle is affected first, followed by the femoral nerve supplying the quadriceps, and lastly the sciatic nerve supplying the hamstrings. This may indicate that the femoral nerve is affected more than the sciatic nerve by the pneumatic tourniquet, thus resulting in a greater loss of muscle strength in the quadriceps than in the hamstrings. This would be in keeping with our finding that the quadriceps strength decreases after surgery whereas hamstring strength was unaltered or increased.

(iv) **The effects of pain**

Moderate pain first inhibits the nerve supply to type I muscle fibres which have a low activation threshold, whereas severe pain inhibits all motor nerve activity to the muscles⁸. Early post-operative pain relief by continuous epidural analgesia may allow muscle activity to resume shortly after surgery and could possibly prevent muscle wasting¹⁰.

3. During isometric hamstring contraction, there was a very marked (fourfold) increase in the right hamstring strength after right knee surgery, but no such change in left hamstring strength after left knee surgery. This

strange finding seems to have no simple explanation, but was also found by Duffin¹⁴.

The increase in hamstring strength may be a compensatory mechanism to increase knee stability in the right dominant leg. Alternatively, the increase may just be a peculiarity of this small subject group and may not be of any practical significance.

4. We found that in the control group the dominant knee produces a significantly greater torque output than the non-dominant knee. The clinician should therefore be concerned with lower extremity dominance and should strengthen an affected dominant knee until its torque output exceeds that of the unaffected non-dominant leg.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that meniscectomy is not a benign procedure that allows the patient to return to previous activities without any long-term ill effects. Few patients in this study had good muscle function on follow-up at least eight months after surgery despite having undergone 'normal' rehabilitative procedures. This indicates that current rehabilitative practices after meniscectomy are inadequate and do not restore full muscle strength after surgery.

The following guidelines are suggested for correcting this:

1. Tourniquet application during surgery: It has been shown that there is a large individual variation in the susceptibility to ischaemia. It would therefore be advantageous to perform surgical procedures for sports injuries without the use of a tourniquet, or to have careful monitoring of the tourniquet pressure and time of application^{11,8}.
2. This study indicates that spontaneous activity, including athletic training, may not be sufficient to restore and maintain muscular function in most subjects. Therefore we suggest that post operative strength training should begin with immediate muscle training a few hours after surgery (in the operating room) under the supervision of a physiotherapist. Continued intensive physiotherapy should be given, the muscles being strengthened at all training speeds (slow, medium and fast velocities) so that the operated leg is fully rehabilitated at all contractile velocities. This will also ensure that all muscle fibre types are recruited and trained. It should be noted that Yocum et al.⁷, showed that patients regained 75% of the pre-operative muscle strength six months after surgery. Very few patients showed further muscle strength improvement beyond six months post-operatively despite continuous training. This may indicate the need for early intensive rehabilitation for up to six months following knee surgery. This may only be practical in completely motivated athletes and not in sedentary individuals.
3. Strict criteria should be applied before athletes are allowed to return to sport. Isokinetic muscle strength should be evaluated and should include testing at slow, medium and fast speeds of both the hamstrings and quadriceps. The dominant leg should be strengthened so that it is able to produce a significantly greater torque output than the non-dominant leg. The quadriceps should produce a greater torque than the hamstrings at each of the three test speeds. The patient must also be tested to ensure that he has sufficient muscle flexibility, muscle endurance and co-ordination to protect the post-surgical knee and prevent re-injury during competitive sport.

The duration of rehabilitation depends on the rate of recovery and the desired muscle strength. Thus, where desired strength is greater (in athletes), intensive rehabilitation for up to 6 months is suggested, but in sedentary individuals rehabilitation need only aim at returning the patient to normal daily activities.

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