



The potential benefit of thermal shrinkage for lax anterior cruciate ligaments

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Radiofrequency thermal shrinkage of the anterior cruciate ligament (ACL) injured knee is a relatively recent treatment. The purpose of this study was to retrospectively analyse the results in a cohort of 32 patients with a minimum follow-up of 12 months (range 12-37 months).

Cases were acute (1) or chronic (31), involving either a native or reconstructed ligament. Native ACL injuries were : lax but intact (12 + 1 acute), partial tears with remaining intact femoral attachment (4) or completely torn and attached to the posterior cruciate ligament (PCL) (6). Reconstructions were : Hamstrings (3), Bone-Patella Tendon-Bone (5) or allograft (1). We also recorded concomitant pathology, function status, Lysholm and Tegner scores and KT2000 values. The procedure was successful in limiting instability overall in 72% (23/32), and in particular 44% of reconstructed ligaments (4/9). There was no correlation of results to the treatment of co-existent pathology. The clinical scores remained high in successful cases although sporting function did reduce by follow-up.

We conclude that despite these results the technique is still of value in appropriately selected, counselled and rehabilitated individuals. It is a safe technique that may avoid the necessity to proceed to reconstruction and can be considered as a planned procedure or as an adjunct to other therapy for instability at the time of arthroscopy for other pathology.

INTRODUCTION

A variety of thermal techniques have been described for the knee including meniscectomy, chondroplasty, lateral retinacular release and syn-

ovectomy. More recently, radiofrequency thermal shrinkage of the ACL has been reported (18). This follows promising early results for capsular shrinkage of the shoulder (5,15). Delivery systems can be monopolar or bipolar. This potentially affects the penetration depth and hence the effect. The duration of treatment, frequency and hence power as well as tissue structure is also relevant (8,12,13). Two case reports refer to early ligament failure following thermal treatment (14,16). Thabit first quoted excellent results in 23 out of 25 patients (19).

Spahn and Schindler (critiqued by Eriksson in editorial comment) used a bipolar technique on elongated isometric grafts in 14 patients and overall had a good outcome in all with a mean follow-up of 23 months (4,17). They advocated the technique as a safe procedure that potentially would prevent the need for reconstruction. Eriksson also quotes work from Bellemans and co-workers, Leuven, Belgium, with a success rate of 43% in

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fourteen cases but the duration of follow-up is unclear. Carter *et al* analysed lax but in-continuity ligaments with pre and postoperative patient scores and KT 1000 measurements (2). There is a follow-up of almost two years, but with a success rate, of only seven out of eighteen patients with a mean failure time of four months. Another paper from the same author in the same year, adding another case to their series, quotes a success rate of eight out of nineteen cases (1). This centre suggests that the technique may only be useful in native ACL injuries if treated within three months of injury. Recommended rehabilitation also varies in the published literature including : 20° flexion in a splint for one month, an extension splint for one month and a three month regime gradually reintroducing activities. Our paper reports on the largest series to date.

PATIENTS AND METHODS

Thirty-two consecutive patients were available for analysis over a period of three years following the introduction of the technique to the department, which performs approximately 300 ACL reconstructions per year. A six-week cut off was selected between acute and chronic injuries. We recorded the state of the ligament: native or reconstructed with a graft. We also made a distinction of the type of tear pattern. Lax but intact tissue had a loss of tension with good origins and no attachment to the PCL. Some patients had partial tears with a visible reduction in tissue bulk or loose fibres, with the remaining attachment to the femur being lax. There were also a few cases with a complete detachment from the femur with good but lax tissue scarred onto the PCL. All patients were operated on by the authors. Thermal shrinkage was either the pre-operative plan or performed with another arthroscopic therapy. All had symptoms of instability and signs of laxity and were advised regarding the current literature. In-patient surgery was planned to allow for immediate reconstruction if found not to be suitable for thermal treatment. Patients with poor quality tissue or poor graft placement were excluded and not followed further by the study. Decisions were individualised further intra-operatively by the authors dependent on demand levels, age and concurrent pathology. No KT measurement was performed routinely as part of the work up for these patients.

Arthroscopy was performed using standard techniques. Thermal shrinkage involved slowly sweeping a

bipolar probe (Mitek, VAPR 3.5mm electrodes, optimal working temperature 63 degrees) lightly along the length of the graft without stopping.

Using an end effect probe, heating commences on the posterior aspect first, as this becomes less accessible with tightening. This is less of an issue with a side effect probe. The entire surface is treated without repeatedly concentrating on one area. A change of texture and tension is noticeable. This process takes around one to two minutes of heating time. Intra-articular local anaesthesia was administered and a splint applied until the individual had recovered from anaesthesia. The first three months involved graduated rehabilitation avoiding open chain or rotational work to achieve range of movement and strength. After three months rehabilitation was case specific with the objective of returning to the pre-injury level.

Patients were recalled for clinical examination and assessment by Lysholm and Tegner scores as well as KT2000 laxitometry. The KT values were for 30lbs. It is well accepted that the KT measurements detect the anteroposterior translation in these injuries but say little regarding the more important rotational component. It is also suggested that there is a large inter- and intra-observer variation in results and these do not necessarily correlate with clinical scores (6,10). Therefore no reliance was placed on the KT values alone during the study, but we quote them in the paper for information to increase the comparability to other articles. Due to the geographical spread of patients referred to our teaching centre, it was not possible to re-examine all individuals. These were scored by post and confirmed verbally. There were no reported ACL injuries to the contra-lateral limb in patients having the KT test. Failures were defined in terms of a history of instability and clinical examination of laxity with a positive pivot shift.

RESULTS

Thirty-two patients were reviewed in excess of one year, with a mean follow-up of 18 months (12-37 months). The study group comprised of a male: female ratio of 5:1 and right: left ratio of 3:2. The mean age at the time of treatment was 25 years (16-42 years) with a time delay from injury to treatment of 13 months. Concomitant pathology was recorded at the time of surgery (table I). Table II summarises the results at follow-up. Twenty-one patients were available for both Lysholm-Tegner score and clinical examination. The mean Lysholm

Table I. – Concomitant pathology (21 cases)

Medial meniscus	
Resection	10
Repair	1
Lateral meniscus	
Resection	3
Repair	0
Synovitis	3
Medial plica	2
Chondral damage	
Patella	2
Trochlea	1
Medial femoral condyle	3
Microfracture	2
Lateral femoral condyle	2
Medial tibial plateau	1
Lateral tibial plateau	0
Medial collateral ligament injury grade II	1
Lateral collateral ligament reconstruction	1

scores for success or failure were 90 and 68 respectively.

At follow-up for all cases there were 9 failures (28%). The overall median time to failure was 6 months (range 2-29). Failures occurred in most subgroups, commonest in the reconstructions. Thirty-three percent of hamstrings and 80% of bone-patella tendon-bone grafts failed giving an overall chronic graft failure rate of 56%. This compares to 17% of native ACLs failing.

Two patients had repeat thermal procedures. Both of these were based on age and the sporting level of the individual and the quality of the graft at the time of repeat arthroscopy. One of these cases, a bone-patella tendon- bone graft went on to fail at 12 months. There were no operative complications and only one failure during the initial three months of the rehabilitation programme. The presence or absence of concurrent pathology did not significantly affect the improvement in clinical score at follow-up.

Groups with or without pathology improved by a score of +14 and +16 points respectively at follow-up. The pre-injury sporting level and the post treatment functional level is demonstrated in fig 1. We were not aware of any further injuries affecting outcome between treatment and follow-up. The level

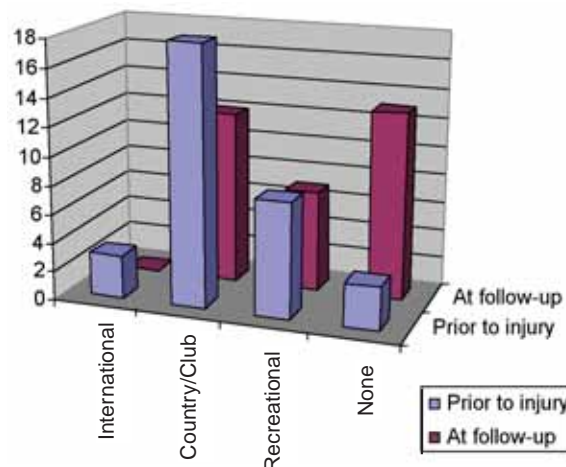


Fig. 1. — Approximate estimates of sporting functional level before treatment and at follow-up.

of function is plotted without any manipulation of the data to compensate for type of anteriorcruciate injury or timescale from surgery.

DISCUSSION

The use of radiofrequency thermal shrinkage of the ACL is a relatively recent technique. Good experimental evidence exists to support micro structural changes in collagen cross-links and helical structure (7,12). The reported tip safe range of temperature (65 to 75° Celsius) and penetration strength has been well defined, at least for capsular collagen (3,12). It is suggested that there is an inflammatory response and subsequent remodelling which stabilises by three months. Despite this, there appears to be little change in the magnetic resonance signal intensity with time after treatment (9).

The most successful clinical outcomes relate to thermal shrinkage of the shoulder capsule in cases of proven instability (5,7,15). Three publications have attempted to clarify the relative merits of the technique for the ACL (2,17,19). There are, however, important differences between these papers: patient selection, country of publication, thermal device used, postoperative regime and outcome scores.

The minimum follow-up of twelve months, twice the median failure time, adds to the validity

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Table II. – Clinical scores and KT 2000 measurements at follow-up with any other relevant history of note (ACI : autologous chondrocyte implantation)

Graft status		Lysholm score pre-operatively	Concomittant pathology (yes/ no)	Lysholm score post-operatively (KT 2000 if recorded)	Follow up time (months)	Failure (months) or other information
Native (23)	Acute lax injury (1)	-	Y	100	18	-
	Lax but intact (12)	-	Y	90 (3)	26	-
		38	Y	35	24	PCL injury 1 week before follow-up.
		-	N	-	20	Works injury
		-	N	90 (2)	14	-
		-	Y	100	16	-
		46	N	69	13	Failed (6)
		84	Y	100	17	-
		-	Y	99	35	-
		-	N	85 (3)	20	-
		-	Y	85 (3)	16	-
		94	Y	94	21	-
		-	Y	61	36	Failed (29)
	Single bundle tear (4)	-	Y	86	27	Subsequent ACI
		89	Y	85 (2)	22	-
		63	N	92	18	-
		64	Y	95 (1)	15	-
	Attached to the PCL (6)	-	Y	86 (1)	12	-
		-	N	89 (2)	12	-
		27	Y	87 (0)	15	-
		75	N	70	12	Failed (6)
		-	Y	90	18	-
		-	N	-	16	Failed (9)
Reconstructions (9)	Hamstring (3)	85	Y	99 (2)	21	-
		68	Y	86 (2)	14	-
		-	N	-	12	Failed (3)
	Bone-Patella Tendon-Bone (5)	-	Y	72	12	Failed (2). Revision BPTB complicated by infection at repeat arthroscopy for cartilage injury
		-				Failed (6)
		70	N	86	13	Failed (2), recent diagnosis of rheumatoid arthritis
		76	N	24	12	-
		-	Y	100	37	-
		49	Y	49	12	Failed (12)
		Allograft (1)	-	Y	59	16

of the study. We did not limit the technique to lax but in-continuity grafts. Some patients had partial tears with a good volume of remaining but lax tis-

sue attached to the femur. Others had a sole attachment by way of scar tissue to the PCL but which was demonstrably lax to probing. The role of

Table III. – General principles of radio-frequency thermal shrinkage of the ACL

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| <ol style="list-style-type: none"> 1. A safe procedure. 2. No specific contra-indications on the basis of graft status. 3. Good quality tissue must be available. 3. May be used as temporising procedure. 4. Aim to treat as much of the cruciate ligament as possible. 5. Splint until recovery from anaesthesia. 6. ACL rehabilitation avoids rotational and open chain exercises for 3 months. 7. Pre-operative advice regarding failure rate essential. |
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surgery for the complete tear is controversial as the tissue is no longer isometric. Out of six cases, all of whom had lax ligamentous tissue, one failed and only two had surgery for purely instability, both of whom benefited from the procedure. Wright and Parry, in a cadaveric study indicated that when the ACL stump is scarred onto the PCL this does not account for the observed reduction in anterior translation seen with these injuries (20). We do question the role of this technique for these injuries, but the limited data does suggest a potential benefit. This also raises important issues regarding the classification of partial tears. Linter *et al* suggest a natural history of progression of elongation and fibre rupture (11). Our belief is that, if a lax ligament is noted, which is of good quality, in a rotationally non-functional knee, there is nothing to lose from treatment. Many patients had concomitant pathology as a dual indication for surgery. By performing pain relieving surgery to this pathology, we felt that it is better to give the individual a tighter functional ligament rather than leaving it lax and discuss at follow-up the options if this became a predominant problem. Therefore the pre-operative assessment must try to establish the degree of instability. Ideally shrinkage should not be based solely on laxity under anaesthesia.

This study does not address the choice of probe, whether monopolar or bipolar. There are genuine concerns regarding penetration depth and the risk of thermal necrosis. We feel that the duration of treatment and keeping the probe moving is more of a determining factor. Although thermal injury to the neural tissue in synovium is of potential con-

cern with respect to proprioception loss, we are not aware of any publication to clarify this issue further.

We recorded our patient sporting levels and injury-to-shrinkage times. Deterioration in function, delay in referral diagnosis, deconditioning and the time waiting for surgery may signify the end of an individual's athletic ability. Fortunately, this is an all too frequent occurrence in the UK practice. We are not aware of any patients changing their occupation following injury or treatment. One patient with a good endpoint had a poor subjective result following an injury at work and on-going accident claim.

We had few individuals in the acute setting. For chronic cases reconstructions fared worse, in agreement with Carter *et al* (2). However, we had a better success with native cruciates, the reasons for which are unclear, partly due to the small sample sizes. Carter concentrated on lax but in-continuity injuries whereas we also included more advanced lax partial tears with some remaining femoral attachment and those with lax scarring to the PCL alone. These also appear to have good results.

One difficulty of this treatment modality is the lack of a suitable control for thermal shrinkage. Although formal ACL reconstruction is the standard treatment for symptomatic laxity, both modalities of treatment are quite different technically. The results of ACL reconstruction are well reported and far better than our thermal results. For this reason, although desirable, a prospective randomised study would not be ethically practical.

Rehabilitation was by dedicated sports physiotherapists. The programme was developed over time by the senior author (D.R.) and previous co-workers in the sports unit. There is no specific evidence as to the best regime for this technique but all authors agree that it makes sense to limit excessive loading for the first three months, in agreement with histological findings of thermally treated tissue from the shoulder capsule. We were not aware of any deviations from this programme unless continued by National club physiotherapists.

Overall, we advocate thermal ACL shrinkage as a safe technique for instability due to lax native or reconstructed ligaments. Patients can be informed

that we report an improvement in subjective instability for *de novo* injuries of 83% and 44% for reconstructions. Although a relatively small study, this is the largest study of its kind from the United Kingdom to date. Although the overall success rate of 72% is not as impressive as one would hope, some patients appear to do well. A careful evaluation of each case is required especially for the reconstructions due to the higher rates of failure. Most patients will understand a smaller day case attempt to improving the situation, rather than proceeding directly to reconstruction. It also prepares the individuals psychologically for a larger operation in the sense that they have exhausted more conservative techniques first. We do not believe that thermal shrinkage delays the inevitable or increases the chance of a more catastrophic injury.

Table III summarises the salient principles of thermal ACL shrinkage. In the light of our results we are sure that the debate will intensify and we look forward to continued interest in this technique.

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