Artificial ligaments for anterior cruciate replacement

A new generation of problems

Rupture of the anterior cruciate ligament (ACL) is a common injury in sport and recreation and its replacement is often, but not always, necessary. Since the first report by Corner in 1914 numerous techniques have been described, but today the bone-patellar-bone autologous transplant appears to be the most reliable. Retrospective studies have shown failure rates as low as 5% to 15% after three to five years (Hackenbruch, Hey and Henche 1990; Shelbourne et al 1990) although the outcome varies with the type of laxity, the surgical techniques used, the surgeon’s experience, the type of rehabilitation and the methods employed to evaluate the patients.

Autologous grafts, however, have some well-recognised drawbacks. Rehabilitation has to be slow to protect the transplant during the first two to three months needed for revascularisation and collagenisation and the socio-economic consequences of a long period off work may be serious, particularly for a professional sportsman. The donor site may also cause problems such as local tenderness, patellar crepitus and pain and weakness of the extensor mechanism.

During the early 1980s, with the development of reconstructive arthroscopic surgery, there was much searching for the ‘elegant solution’ (Larson 1988) and artificial ligaments had considerable appeal. They have the theoretical advantage of immediate strength and therefore a rapid return to full function, and their use avoids the side-effects of harvesting an autologous graft.

There are three types of artificial ligament (McCarthy et al 1993).

Prostheses. These are designed to replace the ligament permanently.

Scaffolds. They provide support for ingrowing tissue, possibly inducing orientated ingrowth of collagen.

Stents. They temporarily protect an autogenous graft from excessive strain during the period of its revascularisation and collagen maturation. The stent can be biodegradable or designed to become physically and mechanically incompetent in a progressive manner.

In 1914, Corner used a silver wire to replace a torn anterior cruciate ligament, and he was the first of many to emphasise one mechanical requirement for cruciate replacement, namely its ultimate strength. Unfortunately he ignored, as have others since, the short- and long-term histological tolerance (acceptance) and all the other mechanical characteristics such as stiffness, creep, elongation to rupture, cold flow, resistance to abrasion (internal and external), fatigue failure, and ageing.

In the USA, the Food and Drug Administration, looking for safety and efficacy, gave approval in 1986 for the general use of Goretex (W. L. Gore, Flagstaff, Arizona) and in 1989 for Dacron Stryker (Meadox Medical, Oakland, New Jersey) artificial ligaments, but restricted their use to patients with failed intra-articular reconstructions. The Kennedy LAD (3M, St Paul, Minnesota) was also approved to augment the autogenous graft used in the Marshall-MacIntosh procedure and later to augment the iliotibial band, the semitendinosus tendon and portions of the patellar tendon used for ligament replacement.

At this time, in Europe, there was no control of the use of artificial ligaments. Persuaded by an excellent marketing system, European surgeons undertook numerous clinical experiments with many designs of implant. Some of the ligaments, but not all, underwent mechanical and biotolerance tests with emphasis on their ultimate strength but very few were tested for the other, equally important, mechanical characteristics. Noyes et al (1984) and Woo et al (1991) clearly established the mechanical behaviour of the bone-ACL-bone unit but the mechanical properties of the artificial ligaments were very different (Table I). They were too stiff, had a low ultimate strain before rupture, and a poor resistance to abrasion.

At first, there were some encouraging reports and the enthusiasm for operative arthroscopic surgery blinded surgeons to what might happen some months or years later. Some of the earlier papers reported toxic intolerance and synovitis (Indelicato and Brown 1992) and artificial ligaments appeared to be ‘technique sensitive’ to any anatomical errors of placement. Paulos, Rosenberg and Grewe (1990) reported increasing effusion rates as follow-up lengthened, so that after four years effusions were present in 34% of knees with Goretex implants.

Olson et al had already pointed out in 1988, on the basis of their experimental models, that wear particles could lead to cartilage destruction. Early elongations and
ruptures were also reported but despite this the use of these ligaments continued to increase.

In the USA in 1990, about 16 000 Goretex, 25 000 LADs and 14 000 Leeds-Keio ligaments (Neoligaments Leeds, Howmedica, Park Royal, London, UK) were implanted (personal communication, Friedman 1990). What have we learned from all this?

**Prostheses**

*Dacron.* Gillquist and Odensten (1993) concluded from their prospective study of Dacron prostheses in 60 patients followed for five years that “the Dacron prosthesis will not give acceptable results in salvage cases where other instabilities are left untreated”. They also drew attention to the importance of correct placement of the prosthesis. Barrett et al (1993), with the same ligament and a four-year review of 40 patients, reported a 60% failure rate and advised against the continued use of the procedure. As in previous studies, synovitis was a serious problem, occurring in 12.5% of the patients (Lukianov et al 1989; Gillquist and Odensten 1993).

Wilk and Richmond (1993) reported the five-year results of a prospective study of 84 patients treated for isolated anterior cruciate laxity or failed previous ligament surgery; the artificial ligament was taken either “over the top” or through drill holes. There was a 37.5% overall failure rate which was even higher (45%) in the patients who had previous surgery and were treated by the over-the-top technique.

Richmond et al (1992) reported a 23% failure rate in isolated anterior cruciate insufficiency and 78% in salvage reconstructions.

*Goretex.* Fox, Karzel and Diefendorf (1990) described 61 patients followed for four years who had a high complication rate (49%) and progressive increase in laxity. Sledge et al (1992) reported a failure rate of 29% in 66 patients at 5 to 7.5 years and concluded that “the early results with Goretex were encouraging but a large number of failures occurred after three years. We currently do not recommend the Goretex ACL for routine primary reconstructions”. Recently, Seemann and Steadman (1993) reported two cases of tibial tunnel widening believed to result from an inflammatory reaction to particulate matter. A form of this ligament is now made with a tighter configuration to reduce the effects of abrasion but Goretex ligaments are no longer available in Europe. Several flexible carbon fibre and xenograft ligaments have also been withdrawn from the market.

Some new prostheses have appeared and are currently under clinical trial: ABC (A. W. Showell (Surgicraft) Ltd, Redditch, UK) (Strover 1992; Mody et al 1993), Apex (DePuy International, Leeds, UK) (Harries and Amis 1993), and Ligastic (Orthomed, Marsannay La Côte, France) (Laboureaux and Dericks 1992). We must await the results of well-designed clinical studies with at least a five-year follow-up to know the value of these implants.

**Scaffolds.** The Leeds-Keio polyester prosthesis (Seedhom 1988), the best-known scaffold, has the potential for tissue ingrowth and therefore for long-term survival (Marcacci et al 1991). Of concern, however, is the mechanical quality of the collagen which grows into the relatively stiffer polyester fibres. The short-term results (Fujikawa 1988; Fujikawa, Iseki and Seedhom 1989) are encouraging if the ligament is used either intra- or extra-articularly. In a recent paper from an independent centre (Paul et al 1993), the results at five years were deemed to be good. In this issue (on page 193), Dandy and Gray report on 129 patients with anterior cruciate deficiency at a mean follow-up of 71 months after reconstruction with the Leeds-Keio prosthesis and an extra-articular MacIntosh lateral substitution. Only 60% of the knees were satisfactory and the pivot shift sign returned in 40%. More studies with a similar follow-up are needed to confirm the efficacy of the ligament.

**Stents.** These have been frequently used although it is doubtful whether they do, in fact, protect ligament transplants during the early phase of vascularisation and collagen maturation.

Some clinical results have been encouraging. Roth et al (1985) compared two similar series of transplants, one with and the other without LAD stents, and found a better subjective result in the LAD group. Cloutier, Lacasse and Normand (1992) reported a five-year follow-up of 40 patients who had reconstruction with semitendinosus and a Kennedy LAD device, finding that 89% had excellent or very good functional results. MacKinlay, Fowler and Roth (1989) in a records and telephone interview of 100 patients at a mean 7.5 years after operation, found good or excellent functional results in 93%. Moyen et al (1992), in a prospective randomised study using the Marshall-MacIntosh procedure, with or without LAD, found no objective or subjective difference. Field and Barrett (1993) using patellar tendon and Santi and Richardson (1993) using hamstring grafts had similar results.

**Failed artificial ligaments.** Even if you have not implanted any artificial ligaments that does not mean that
you will not have to take one out! If you do, you may have to take account of the following problems: the type of joint laxity (which may be complex); the presence of synovitis; the position of the bone tunnels (often greatly widened); residual ligament fixation devices; and a degree of cartilage degeneration (Olson et al 1988).

It is necessary to have a good preoperative plan, based on weight-bearing radiographs, tunnel views, CT and possibly MRI. Diagnostic arthroscopy is mandatory before proceeding to reconstructive surgery.

One-stage reconstruction of the ACL may be possible using bone-patellar tendon-bone autologous graft, perhaps with additional repair of the secondary restraints of the knee. A two-stage procedure may be necessary if there is either severe synovitis, requiring complete removal of the prosthesis and synovectomy, or abnormally sited or severely widened bone tunnels which necessitate bone grafting before delayed ACL reconstruction. If there is serious cartilage degeneration, an osteotomy may be appropriate along with an ACL reconstruction.

By the time that major surgery is needed the patient has travelled a long way from his original symptoms of isolated ACL insufficiency. We now have to pay the bill for the failure of short-term, poorly controlled experiments with ligament replacement.

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REFERENCES


