neoligaments™

Autografts, allografts and synthetics

A brief review of their attributes

Introduction

A surgeon has a number of choices of graft material when performing soft tissue repair, including autografts, allografts and synthetics.

There is currently no optimum graft that will suit every patient. The advantages and disadvantages of the different grafts can therefore be assessed, taking into consideration the patient's occupation, sporting activities, rehabilitation potential, desired postoperative activity level, skeletal age, associated ligamentous pathology, inherent degree of ligamentous laxity, and history of previous repair. These factors can be discussed with the patient in order to help select the appropriate graft.

This article presents an overview of the advantages and disadvantages of these various options. Although the majority of these topics are universal, they are particularly aimed at ACL reconstruction.

References concerning this debate are widely available. Therefore, only a few key references are included for illustrative purposes.

Graft advantages and disadvantages

Parameters compared	Autografts	Allografts	Synthetics
Uniformity of dimensions Lengths and cross sectional areas	Variable between patients.	Variable between donors.	Consistent dimensions
Uniformity of properties Strength and stiffness	Variable with anatomical site and patient age.	Variable with anatomical site, donor age and tissue processing conditions.	Consistent mechanical properties
Control of graft properties	• Variable, dependent on patient anatomy and choice of graft. • Some grafts, for example the hamstrings, can be doubled up to increase strength.	• Governed by quality of supplied tissue. • Some grafts, for example the hamstrings, can be doubled up to increase strength. • Range of tissue available with alternative sizes and strengths.	• Choice of graft with appropriate dimensions and mechanical properties for specific applications is possible • Bespoke designs are also available

Parameters compared	Autografts	Allografts	Synthetics
Supply issues	Typically no supply issues, but problems arise if: • graft was incorrectly harvested (cut short, or too thin); • patient's tissues are not suitable for harvest (e.g. Polio); • multiple revision has left no tendons to harvest; • multiple ligamentous injuries have occurred which require multiple reconstructions.	Rigorous screening process is necessary to guard against disease transmission, resulting in a limited supply.	No supply issues. Abundantly and immediately available, in different sizes with different properties suitable for different applications. Especially effective with cases of multiple ligamentous injuries requiring multiple reconstructions.
Immediate postoperative graft performance	Graft undergoes a process of necrosis, revascularisation, fibroblast invasion and collagen synthesis. This results in decreased graft strength in the immediate post-operative period which dictates the pace of the rehabilitation regime. Typically, the strength decreases to less than 15% by 8 weeks. In the long term it only climbs back to 30 - 40 % after 8 to 24 months of implantation [Newton et al 1990].	Graft undergoes a process of necrosis, revascularisation, fibroblast invasion and collagen synthesis. This results in decreased graft strength in the immediate post-operative period which dictates the pace of the rehabilitation regime. Graft strength follows a similar path to that of the autograft and so decreases to some 15% of its original value by approximately 8 weeks after implantation. Even in the long term it only climbs back to 25 - 35 % after 12 months of implantation [Newton et al 1990].	Strength of the prosthesis remains high over the initial postoperative period and tissue ingrowth further increases the strength [Seedhom et al 1984].
Rehabilitation regime	Slow, to allow revascularisation, recellularization, remodelling and the recovery of strength to take place. .	Slow, to allow revascularisation, recellularization, remodelling and the recovery of strength to take place.	• Almost immediate return to daily activities. Implant strength is high and does not drop off but increases due to tissue ingrowth and remodelling. • Typically no need for casts or braces.

Graft advantages and disadvantages

Parameters compared	Autografts	Allografts	Synthetics
Risk of disease transmission This is heightened by an incubation period for some diseases - 'window' periods between exposure to these viruses and the production of detectable antibodies (surface antigen for HBV) in the serum. These are 21 days for HIV, 35 days for HBV, and 75 days for HCV) [Allain 1998]	None.	Present and could potentially be serious: The estimated probability of viremia at the time of tissue donation is: 1 in 55,000 for HBV; 1 in 34,000 for HCV; 1 in 42,000 for HIV and 1 in 128,000 for HTLV [Zou et al 2004]. The current risk of transplanting tissue from an HIV-infected donor has been reported to be 1 in 173,000 to 1 in 1,000,000 [McAllister et al 2007]. Moreover, there are recent concerns over some of the emerging pathogens as there is little data available and no validated screening tests for prion diseases associated with transmissible spongiform encephalopathies such as Creutzfeldt-Jakob disease and its variants. Although the risk of acquiring such diseases is currently unknown it is likely to be extremely low due to their rarity [McAllister et al 2007]. Furthermore, not all tissue banks apply for AATB accreditation. In 2002, approximately 10% of musculoskeletal allografts were processed by non-accredited tissue banks [Joyce et al 2004]. It was demonstrated that infections acquired through bacterial contamination of allografts have the potential to result in substantial complications or even death [Kainer et al 2004]. The study recommends that current regulations and standards for processing and testing allograft tissue need to be improved to prevent such life-threatening allograft-associated infections.	None.

Parameters compared	Autografts	Allografts	Synthetics
Potential immune response complications	None.	Present, since it is not possible to achieve 100% decellularization of the graft. This problem is lessened through the use of anti-rejection drugs.	Very rarely there may be a short-lived foreign body reaction that subsides gradually after implantation. True allergenicity is very rare.
Donor site morbidity	Harvesting tendon reduces the strength of existing structures and can cause pain at the site of harvest. BTB graft specific problems include: anterior knee pain in 4-40% of cases, patellar tendinitis, patellar fracture, patellar tendon rupture and loss of quadricep power [Bartlett 2001]. Hamstring graft issues include: weakness of the hamstring muscles [Bartlett 2001], reduced proprioception creating instability when running backwards.	None.	None.
Cost effectiveness	No cost for the actual graft. However, additional costs can be incurred due to longer procedure and operating room (OR) time. Furthermore, the loss of earnings due to long rehabilitation periods, especially in the case of a professional sportsman/woman, might be considerable.	Typically £1500 per implant. However, Cole et al [Arthroscopy 2005] analysed the overall healthcare economics of the use of allografts for ACL reconstruction. They noted that the use of allografts led to shorter operating theatre times and a reduced average length of hospital stay, and concluded that the use of allografts was less expensive overall than using autograft. The most direct and apparent cost from the patient's perspective, however, is the initial cost of the graft, which in the USA is charged by the hospital to the patient or their insurance company.	Typically £1000. But shorter OR and rehabilitation time results in lower overall treatment cost and reduced loss of earnings compared with reconstructions using autografts or allografts.
Surgery time, graft preparation	Typically, it takes 20 minutes for graft harvest, graft preparation including whip stitching, sizing and conditioning via cyclic loading. This is additional to the time taken to implant the graft.	While this is shorter, further time is taken to prepare the graft including trimming to size and conditioning. Additionally, careful planning is needed to defrost graft on time.	Shortest as no graft harvest or preparation are required. Also due to consistent size and strength, standard tunnel preparation with minimal instrumentation is possible.

Graft advantages and disadvantages

Parameters compared	Autografts	Allografts	Synthetics
Incisions: size and number	More incisions are required than with other grafts. This is due to the harvesting procedure. The largest incisions are made when harvesting a BTB graft.	Few and small in size.	Few and small in size.
Infection risk	Low – determined primarily by the environment.	Highest; allogenic tissue cannot be sterilized via ethylene oxide gas treatment and gamma irradiation like other metallic or polymeric medical devices without destroying the tissue's mechanical and biological properties [Rasmussen et al 1994; Fideler et al, 1995]. Moreover, ethylene oxide has a limited capacity to penetrate tissue and has been associated with adverse patient outcomes such as chronic synovitis [Jackson et al]. To overcome these potential issues several tissue banks have recently developed controlled-dose, low-temperature sterilization approaches (eg. Allowash XG from LifeNet Health).	Low – determined primarily by the environment.
Storage and handling	N/A.	Needs cold storage facility, typically below -60°C. [California Transplant Services, 1994; LifeNet]. Before use, it should ideally be defrosted overnight in a refrigerator and kept for 2 hours at room temperature.	Immediately available. 5 years shelf life. Stored at ambient temp on OR shelf. The Neoligaments plasma treated implants (providing enhanced cell growth) require storage between 5 and 30 °C.
Reproducibility of results	Variability in tissue can yield inconsistent results	Variability in tissue can yield inconsistent results	Each device has consistent mechanical properties, giving reproducible clinical results.

References

Newton PO, Horibe S, Woo S L-Y. Experimental Studies on Anterior cruciate ligament autografts and allografts. Mechanical studies. In: Daniel DM, Akeson WH, O'Connor JJ eds. *Knee ligaments: Structure, Function, Injury and Repair.* New York: Raven Press; 1990:389-399.

Seedhom BB, Fujikawa K, Atkinson PJ. The Leeds-Keio artificial ligament for replacing the cruciates. In: *Engineering and Clinical Aspects of Endoprosthetic Fixation.* London, UK: Mechanical Engineering Publications Limited; 1984:99-110.

Degner LF, McWilliams ME. Challenges in conducting cross-national nursing research. In: Fitzpatrick JJ, Stevenson JS, Polis NS, eds. *Nursing Research and its Utilization: International State of the Science.* New York, NY: Springer; 1994:211-215.

Poulsen MR, Johnson DL. Graft Selection in Anterior Cruciate Ligament Surgery. *Orthopedics.* 2010;33(11):832-835.

Lawhorn KW and Howell SM. Autograft and Allograft ACL Reconstruction: Construct Rationale. In: Pietrzak WS ed. *Musculoskeletal Tissue Regeneration, Biological Materials and Methods.* Totowa, NJ: Humana Press; 2008:395-417.

Zeigler T. Why Some ACL Surgeries Fail, Patient or Professional Error. http://www.suite101.com/content/why-acl-surgeries-fail-a121724. Updated May 31, 2009. Accessed December 8, 2010.

Koenig MD, Harner CD. Graft Choices. In: Fu FH, Cohen SB eds. *Current Concepts in ACL Reconstruction.* Thorofare, NJ: SLACK Incorporated; 2008:147-158.

Allain, JP. Screening blood for viral genomes: which way to go? (Editorial). *Transfus Med.* 1998;8(1):5-7.

Zou S, Dodd RY, Stramer SL, Strong DM; Tissue Safety Study Group. Probability of viremia with HBV, HCV, HIV, and HTLV among tissue donors in the United States. *N Engl J Med.* 2004;351(8):751-759.

McAllister DR, Joyce MJ, Mann BJ, Vangsness CT Jr. Allograft update: the current status of tissue regulation, procurement, processing, and sterilization. *Am J Sports Med.* 2007;35(12):2148-2158.

Joyce MJ, Rigney R, Greenwald AS, et al, for the Committee on Patient Safety, Committee on Biological Implants, and Tissue Work Group. Musculoskeletal allograft tissue safety. Handout presented at: American Academy of Orthopaedic Surgeons; San Francisco, CA; March 2004.

Kainer MA, Linden JV, Whaley DN, Holmes HT, Jarvis WR, Jernigan DB, Archibald LK. Clostridium infections associated with musculoskeletal-tissue allografts. *N Engl J Med.* 2004;350(25):2564-2571.

Bartlett RJ, Clatworthy MG, Nguyen TNV. Graft selection in reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br.* 2001;83(5):625-634.

Cole DW, Ginn TA, Chen GJ, Smith BP, Curl WW, Martin DF, Poehling GG. Cost comparison of anterior cruciate ligament reconstruction: autograft versus allograft. *Arthroscopy.* 2005;21(7):786-790.

Rasmussen TJ, Feder SM, Butler DL, Noyes FR. The effects of 4 Mrad of gamma irradiation on the initial mechanical properties of bone-patellar tendon-bone grafts. *Arthroscopy.* 1994;10:188-197.

Fideler BM, Vangsness CT Jr, Lu B, Orlando C, Moore T. Gamma irradiation: effects on biomechanical properties of human bone-patellar tendon-bone allografts. *Am J Sports Med.* 1995;23:643-646.

Jackson DW, Windler GE, Simon TM. Intraarticular reaction associated with the use of freeze-dried, ethylene oxide-sterilized bone-patella tendon-bone allografts in the reconstruction of the anterior cruciate ligament. *Am J Sports Med.* 1990;18:1-10.

LifeNet Health. Validation of storage, packaging containers and transportation. Instructions For Use leaflet packaged with implant. 65-0067 REV. 000/07-07. http://accesslifenet.org/images/cache/WTI999-3009cc8dd65-0067.pdf. Updated October 25, 2007. Accessed December 8, 2010.

California Transplant Services, Inc. Frozen bone and soft tissue allograft. Instructions For Use leaflet packaged with implant. http://www.catransplant.org/FROZEN.DOC. Updated October 5, 1994. Accessed December 8, 2010.

Neoligaments™
A division of Xiros™
Springfield House
Whitehouse Lane
Leeds LS19 7UE UK

Tel. +44(0)113 238 7202
Fax. +44(0)113 238 7201
enquiries@neoligaments.com
www.neoligaments.com

Registered in England No.1664824