Improving the Patency of Vascular Bypass Grafts: the Role of Suture Materials and Surgical Techniques on Reducing Anastomotic Compliance Mismatch

A. Tiwari, K.-S. Cheng, H. Salacinski, G. Hamilton and A. M. Seifalian*

Tissue Engineering Centre, University Department of Surgery, Royal Free and University College Medical School, University College London and The Royal Free Hospital, London, U.K.

Background: compliance mismatch is an important factor in the development of myointimal hyperplasia in both coronary and vascular anastomoses. This mismatch may be reduced by the use of newer suture materials and techniques. This review discusses the current techniques and materials used to date in generating anastomoses in both coronary and vascular applications and to correlate these with the degree of inherent compliance achieved.

Methods: PubMed, ISIS, CAS and PAS database searches were performed. Other articles were cross-referenced.

Results and conclusion: continuous suture is still the most used technique in both cardiac and vascular surgery for the generation of anastomoses due to the reduced time and improved haemostasis. However, continuous suture results in a greater compliance mismatch than the interrupted technique. Vein cuffs and patches improve compliance and transmission of pulsatile blood flow and offer improvement of graft patency. Alternative to sutures are biological glue, clips and laser generated solders all of which have shown promising results, but further work is required before they become applicable for routine use.

Key Words: Compliance; Suture; Clips; Glue; Myointimal hyperplasia; Polyurethane; Anastomosis; Laser; Solder.

Introduction

The prevalence of coronary and peripheral vascular disease (PVD) is increasing due to the rise in the aged population. This has led to a larger number of patients requiring surgical bypass commonly using autologous conduits. In coronary artery bypass grafting (CABG) this is usually internal mammary artery or saphenous vein whilst for PVD it is usually saphenous vein. If autologous vessel is unavailable then a prosthetic graft typically expanded polytetrafluoroethylene (ePTFE) or poly(ethylene terephthalate) (Dacron) is used in PVD whilst prosthetic grafts are rarely used in CABG.

The results of above knee femoropopliteal bypasses using either vein or prosthetic graft are comparable whilst that of below knee femoropopliteal or femorodistal bypass with prosthetic grafts is considerably worse as compared to autogenous vein.1-5 The results of prosthetic graft in CABG are very poor and thus routinely not undertaken. One of the most important causes of graft failure is due to the development of myointimal hyperplasia (MIH) at the anastomosis especially in the distal anastomosis.6-11 This is seen as a cause of failure in both autogenous and prosthetic bypass grafts though vein graft also suffer from stenosis at sites away from the anastomosis.12 MIH affects mainly the heel and toe of the graft and the floor of the artery and consists of myofibroblasts, collagen fibres, endothelial cells (EC) and smooth muscle cells (SMC).6,8,13,14 This response is maximal during the first few weeks after bypass before the graft wall thickness becomes constant.15,16 The intimal thickening is higher when prosthetic grafts are used in the vascular bypass.13

An important factor implicated in the development of MIH is a compliance mismatch between the native vessel and the graft leading to adverse local
haemodynamic effects at the anastomosis with consequent greater intimal thickening and eventual graft failure.13,17±22

The compliance mismatch is not only between the stiffer bypass graft and the artery but also at the anastomosis itself. At this site, there is a hypercompliant zone lying 1±4 mm proximal and distal to the suture line which has been termed the para anastomotic hypercompliant zone (PHZ).19 This is shown diagrammatically in Figure 1.

It has been postulated that this is caused by the compliance of the graft being significantly reduced at the anastomosis mainly due to the suturing material or suturing technique resulting in haemodynamic changes around the anastomosis.19,23,24 Of further importance is the fact that the compliance of any bypass graft further reduces after a few weeks of implantation due to peri-prosthetic reaction such as scarring and graft incorporation.18,21,25 This is especially worse for prosthetic graft where compliance of ePTFE is reduced to 14% and Dacron to 29% of its pre-implantation levels after only 3 months of implantation.26 The commonly used prosthetic bypass grafts to date have had compliance significantly lower than the native artery with the vein having the best compliance. The compliance of the commonly used bypass grafts are summarised in Table 1.

There has been a great deal of work recently on developing more compliant sutures, suturing techniques, mechanical clips, biological glue and laser based solder techniques. The aim of this has been to improve pulsatile laminar blood flow in arteries propagation across the anastomosis and to reducing damage to the surrounding endothelium. This review discusses these strategies in improving the compliance and correlates this with the degree of improved compliance they are able to achieve and also discusses newer compliant prosthetic grafts. It should be emphasised that this review examines problems of compliance mismatch which related to arterial reconstruction in the extremities, including the carotids and also to the heart: but not in abdominal aortic surgery, where haemostasis is of prime importance and prosthetic materials and continuous sutures work well with patency assured.

**Methods**

All the studies were identified by PubMed, ISIS and CAS searches between years 1966–2002 with the following keywords: compliance, suture, glue, clips, laser, vascular, shear stress, myointimal hyperplasia and anastomosis. Other references were extracted from the retrieved papers.

---

**Table 1. Compliance (%/mmHg x 10^2) of commonly used bypass grafts. Data presented in Mean ± SD or in range (min.–max.).**

<table>
<thead>
<tr>
<th>Author</th>
<th>Artery</th>
<th>Vein</th>
<th>PTFE</th>
<th>Dacron</th>
<th>Polyurethane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidson et al., 1978&lt;sup&gt;26&lt;/sup&gt;</td>
<td>7.4 ± 0.7</td>
<td>2.7 ± 0.2</td>
<td>1.6 ± 0.1</td>
<td>1.9 ± 0.2</td>
<td>n.a.</td>
</tr>
<tr>
<td>Kinley et al., 1980&lt;sup&gt;21&lt;/sup&gt;</td>
<td>13.6–26.8&lt;sup&gt;*&lt;/sup&gt;</td>
<td>4.8–6.1</td>
<td>n.a.</td>
<td>3.4–4.1&lt;sup&gt;†&lt;/sup&gt;</td>
<td>n.a.</td>
</tr>
<tr>
<td>Walden et al., 1980&lt;sup&gt;09&lt;/sup&gt;</td>
<td>5.9 ± 0.5</td>
<td>4.4 ± 0.8</td>
<td>1.6 ± 0.2</td>
<td>1.9 ± 0.2</td>
<td>1.1–1.5&lt;sup&gt;‡&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tai et al., 2000&lt;sup&gt;98&lt;/sup&gt;</td>
<td>19.3 ± 11.9&lt;sup&gt;¶&lt;/sup&gt;</td>
<td>21.0 ± 11.0</td>
<td>1.8 ± 0.2</td>
<td>1.9 ± 0.7</td>
<td>8.0 ± 0.4</td>
</tr>
<tr>
<td></td>
<td>2.6 ± 0.8</td>
<td>1.5 ± 0.4</td>
<td>0.9 ± 0.1</td>
<td>1.9 ± 0.2</td>
<td>8.1 ± 0.7</td>
</tr>
</tbody>
</table>

n.a. not available.
* Thoracic aorta in man, age 20–60 yrs.
† Double velour Dacron.
‡ At mean blood pressure of 30 mmHg.
¶ At mean blood pressure of 100 mmHg.
Mechanical behaviour of vascular systems

Theoretical considerations

Before discussing the effect of suture material and techniques on compliance at graft anastomoses, it is important to understand the basic properties and definitions in cardiovascular systems. Different materials have varying levels of elasticity and this is defined as the ratio of applied stress to resultant strain that is the Young’s modulus, which is measured in dyn/cm². If a material regains its original dimensions when the original stress is withdrawn it is termed elastic, whilst those, which retain this deformation, are termed plastic. However when stress is applied to a fluid it undergoes viscous flow. The vessel wall will then exhibit properties of both elastic solid and a viscous fluid and is then described as being viscoelastic.

In attempting to understand the biophysics of blood vessels in vivo, a variety of measurements have been derived leading to a debate over the best index for measuring arterial properties, as well as to confusion in the comparison of results between studies.27,28 The concept of compliance has been introduced clinically in order to define this complex physical phenomenon. Compliance (C) is a mechanical property of a tube that expresses a dimensional change with respect to luminal pressure change.9 Traditionally defined as:

\[
C(\% \text{mmHg}^{-1} \times 10^{-2}) = \frac{(D_s - D_d)}{D_d(P_s - P_d)} \times 10^4
\]

where \(D, P, s\) and \(d\) denote diameter, pressure, systole and diastole, respectively.

Causes of graft failure in terms of mechanical behaviour

Compliance mismatch comprises of two major parts, tubular and anastomotic. Tubular compliance mismatch refers to resistance to pulsatile flow. This predominantly occurs at the interface between the compliant artery and the surgically generated anastomosis with the bypass conduit resulting in the propagation of only 60% of the original pulsatile. Anastomotic compliance mismatch is when there is a focal decrease in diameter and drop in compliance due to the stiffness of the suture employed and the surgical technique leading to PHZ as already discussed.

As a result of both of these two components of compliance mismatch, the local shear stress conditions alter and coupled with the growth of tissue and corresponding remodelling at the anastomosis leads to MIH. This is more prevalent for prosthetic bypass grafts because of the greater degree of compliance mismatch.

Methods of generation of surgical anastomosis

Current surgical anastomotic interventions for cardiovascular reconstructions usually utilise a monofilament suture such as polypropylene (Prolene™), or polybutester (NovafilTM) either as an interrupted or continuous technique for both coronary and vascular bypass. Both of these results in the inevitable presence of foreign material at the blood graft interface and direct intimal damage exposing thrombogenic extracellular matrix to turbulent blood flow. Other sutures, which are not so commonly used or have only been used experimentally, include those made from PTFE and absorbable sutures made from materials such as polytrimethylene carbonate.29,30 There is a lack of data on compliance regarding these latter sutures and thus are not discussed further.

Suture techniques

(a) Continuous vs. interrupted anastomosis. The advantages of the continuous suture compared to the interrupted suture are the reduced time for surgery and less risk of bleeding from suture lines. The disadvantage is that it can produce a purse-string effect and thus impair haemodynamic effect at the anastomosis.31 The anastomotic diameter is lower with the continuous suture.32,33 In continuous suture, PHZ is seen in 86% of the anastomoses compared to 50% of the anastomoses using an interrupted technique.33 This is because continuous suturing leads to a greater decrease in the compliance at the anastomosis.33,34 The PHZ was however not always present on both sides of the anastomoses.

Tozzi and co-workers also compared continuous suture with interrupted suture delivered through an automated device, Heartflo™.31 This is however still slower than performing a continuous suture. The interrupted suture had a smaller mean cross sectional area compared to running suture whilst the compliance was higher for the interrupted suture. They found that the vessel diameter at an end-end anastomosis decreased when blood pressure increased resulting in negative compliance at the anastomotic site and this was attributed to using a continuous suture.34

(b) Anastomotic cuffs and patches. In an attempt to improve the long-term patency of in particular peripheral arterial bypasses a number of different anastomotic techniques utilising venous cuffs or patches have been used including Taylor patch, Linton patch; Karacagil cuff; Miller cuff and St Mary’s boot.35–38 These function by taking venous material in a transverse orientation in order to develop a gradual transition of compliance and to facilitate the actual anastomosing of the arterial vessel with either the...
autologous conduit or polymeric graft with different diameter and wall structure. The other advantage of cuffs and patches is to cushion any effect of kinking such as across the knee in flexion, when a stiff PTFE graft is sewn to a supple popliteal artery. These patches and cuffs have shown improved graft patency at the distal anastomosis this being most likely to the improved blood-flow and corresponding compliance.37,39–46 Others have argued that the improvement in graft patency due to cuffs and patches is not due to the mechanical property of the vein but rather due to its biological property though this issue still remains unresolved experimentally.47,48 The patency rates using the various patches/cuffs range from 35–87% when used in both popliteal and tibial bypass.35,37,49–51 Noori and co-workers showed that the flow patterns for the Taylor and Linton patch are similar to conventional anastomosis whilst the Miller cuff shows a persistent washout of the anastomotic cavity that may have the added advantage of reducing thrombogenicity.52

(i) Linton patch. Linton described a patch technique in which the autologous conduit is patched with a venous segment of around 40–50 mm in length.38 The maximal compliance using the Linton Patch is 9.5 ± 2.3 (graft compliance 1.4 ± 0.5, arterial compliance 4.5 ± 1.5).45 The clinical patency using this technique is between 65–74% bases on the site of the anastomosis.49

(ii) Miller cuff. The Miller cuff results in both increased blood flow and improved compliance leading to less MIH.44–46 The maximal compliance using the cuff is 9.8 ± 2.7 (normal graft 1.3 ± 0.6, artery compliance 4.9 ± 1). Tyrell and co-workers have suggested that the Miller Cuff optimises the mechanical property of the vein graft and protects small arteries from anastomotic distortion.44 The patency rates of grafts utilising the Miller cuff range from 29–72% depending again on the location of the anastomosis.35,39,50,53

(iii) Taylor patch. The Taylor patch has shown 5-year patency rates on ePTFE rafts of 71% in femoropopliteal and 54% for infra-popliteal grafts in the original work by Taylor and co-workers.32 Others have shown that graft patency with technique is 51–71%.54,55 The advantages of this patch mirror those of the Miller cuff in that it enhances the mechanical properties of the vein.

(iv) St Marys boot. Tyrell and co-workers designed a new venous collar that incorporated the advantages and eliminated the disadvantages of previous cuff and patches such as the Miller and Taylor.44,56 No data on its compliance is available though it does show improved blood flow and an enhanced biphasic haemodynamic flow pattern.57

(v) Karacagil cuff. Karacagil and co-workers have also modified the Miller technique and shown promising results.58,59 However no data is available on its effect on intimal healing, compliance, or haemodynamic flow characteristics.

Anastomotic materials

(a) Polypropylene and polybutester suture. We have already discussed the use of these materials with respect to continuous and interrupted techniques. In this section we discuss the merits of Polypropylene (the commonly used suture) and Polybutester (not commonly used). Both the suture show the same degree of strength though polybutester is more compliant.32,60 Megerman and co-workers compared continuous polybutester and polypropylene sutures both in vitro and in vivo.61 In vitro artery–artery anastomosis showed no significant difference between diameter proximal and distal to the anastomosis and no PHZ was seen. However the compliance at the anastomosis was significantly better with polybutester (5.9% ± 2 vs. 3.3 ± 0.6). In vivo similar significant results were seen with the polybutester suture having 4/8 PHZ zones whilst 2/8 with polypropylene. In vein to artery graft no difference was seen in the compliance. Intimal thickening was greater in the distal portion of the anastomosis but no difference in the intimal hyperplasia was found between the polybutester and polypropylene sutures.61

Baumgartner and co-workers found no difference in the compliance of anastomosis when polybutester and polypropylene sutures were used in end to side anastomosis at pressures of 50–200 mmHg.62 Morasch and co-workers also compared Novafil and Prolene suture in continuous and interrupted technique in spatulated or bevelled anastomosis and found no difference in dimension and compliance of the anastomosis.62 However when using ePTFE for end-to-end anastomosis, they found that when the graft that is being used is slightly larger than the artery, it gives the largest and smoothest anastomosis. However in this study, no beneficial effect was seen with the different suture types or techniques.63 In such an anastomosis, compliance mismatch occurs mainly between the ePTFE side and artery side of the anastomosis with ePTFE having nearly zero compliance.

(b) Clips. The application of metal clips as an alternative to suture is one that would make the construction of the anastomosis easier and more

Eur J Vasc Endovasc Surg Vol 25, April 2003
rapid for the surgeon and this was first investigated in 1955. However, the technique was not widely employed because the clips penetrated through the wall and damaged the endothelium at the point of anastomosis. The re-emergence of interest in clips has been because of the development of non-penetrating clips and their subsequent successful use in neurosurgery. These new clips produce a focal and interrupted compression of the everted tissue walls without penetration of the vessel lumen.\textsuperscript{64,65} Vascular clips have been used in other branches of surgery including use in coronary anastomosis, haemodialysis access, and carotid patch angioplasty.\textsuperscript{66-71} Recently, trials of these clips are becoming available for peripheral bypass procedures.\textsuperscript{72-74} The lack of their popularity for clinical use in peripheral bypass was because of the relative difficulty in using the clips in the atherosclerotic calcified vessels where apposition of the vessels is harder and eversion of the vessel much more difficult to perform surgically.\textsuperscript{72,74} The main advantage of clips for anastomosis are the reduced time for surgery, more streamlined anastomosis and immediate haemostasis.\textsuperscript{15,65,68,71,73,75-80} Because they do not penetrate the vessel wall, the further advantage of the clips is less disruption of the endothelial layer and thus potentially preventing MIH.\textsuperscript{65,78,81} Using clips also reduces the complications associated with treatment of arterial “steal syndrome”.\textsuperscript{68} It does however require precise vessel preparation and supervised training and the initial cost is slightly higher.\textsuperscript{64,73} There is however no difference in patency rates or intimal thickness when comparing clips to interrupted suture\textsuperscript{15,67,76} though Komori and co-workers found significantly less intimal thickening in patients with clip anastomosis compared to interrupted suture when used in a “poor run off” canine model.\textsuperscript{79} The volume blood flow rates through the vessel between clip anastomosis, continuous and interrupted sutures are significantly different.\textsuperscript{15,65,77,78}

Baguneid and co-workers compared the immediate compliance of non-penetrating clips to polypropylene sutures in an animal model\textsuperscript{65} and showed that compliance was better with clips compared to continuous suture but not so with interrupted suture. No significant difference was found between the blood flow between the three types of suture.

Zeebregts and co-workers compared the effect of clips and interrupted suture on the endothelium function and intimal hyperplasia\textsuperscript{75} and found that the endothelium dependant relaxation was 2.8 times more in the clipped group though this was not significant. No significant difference was seen between the intimal media thickness in the two groups. When Izzat and co-workers compared clips to continuous sutures after one week,\textsuperscript{82} electron microscopy showed that both the groups had luminal coverage of endothelial cells but in the sutured anastomosis suture material was still visible in the lumen which may lead to increase thrombogenicity.

The results of the above studies are summarised in Table 2.

\textbf{(c) Lasers.} Lasers have begun to be investigated as a means of generating anastomoses by tissue welding in both vascular and coronary bypasses.\textsuperscript{83,84} Using a laser reduces the time for the anastomosis but the compliance profiles are similar as for sutures.\textsuperscript{85} Dalsing and co-workers have used interrupted suture and compared it to a laser anastomosis and found no significant advantage of the laser technique.\textsuperscript{86} The main problem with laser anastomoses were the risk of rupture because of weakness or associated with the technique\textsuperscript{87} though the problems can be overcome by the use of adding a chromophore.\textsuperscript{88} The healing of this anastomosis is by myofibroblast proliferation and it demonstrated complete endothelialisation compared with the sutured anastomosis, which resulted in a fibrotic build up.

Further, in order to prevent the thermal damage created by lasers particularly to proteins present in the tunica media and adventitia, chromophores in particular fibrinogen,\textsuperscript{88} albumin and methylene blue (MB) have been added these acting as energy modifiers causing a solder effect to occur.\textsuperscript{84,89-91} The chromophore in protein solders allows it to act as a heat generator by absorbing any incident photon energy, thus becoming excited and generating thermal energy, this causing solidification. Furthermore, coloured chromophores such as MB cause photobleaching thus giving a visible end point. A study has demonstrated that MB solder produces anastomoses with immediate burst pressure profiles similar to those seen in conventionally sutured, lasered and laser soldered anastomoses.\textsuperscript{92} The future of laser generated anastomoses currently still lies with the combined usage with conventional continuous suture.

\textbf{(d) Glue.} The glues used to date to construct compliant anastomoses include 2-octyl-cyanoacrylate\textsuperscript{93} and gelatin-resorcin-formaldehyde with a collagen-sheet adjunct.\textsuperscript{94} Using glue results in quicker anastomoses.\textsuperscript{94} The work by Oiwa and co-workers showed that using glue results in good pressure resistance and tensile strength.\textsuperscript{94} When this glue was compared to a continuous suture, there was no stenosis or leakage with the glue. Endothelialisation was complete after 4 weeks with a smooth surface whilst the suture line remained irregular. There has been no data on the
<table>
<thead>
<tr>
<th>Author</th>
<th>Type of A</th>
<th>C at A</th>
<th>C proximal to A</th>
<th>C distal to A</th>
<th>Species</th>
<th>Type of prosthetic graft</th>
<th>Type of A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klein et al., 1982</td>
<td>Interrupted Prolene</td>
<td>5.5±2.8</td>
<td>9.4±0.8</td>
<td>8.9±0.6</td>
<td>Canine</td>
<td>Artery</td>
<td>End-end</td>
</tr>
<tr>
<td>Klein et al., 1982</td>
<td>Continuous Prolene</td>
<td>2.7±1.3</td>
<td>9.6±3.1</td>
<td>7.4±1.9</td>
<td>Canine</td>
<td>Artery</td>
<td>End-end</td>
</tr>
<tr>
<td>Hasson et al., 1986</td>
<td>Interrupted Prolene</td>
<td>4.7±2.2/10²</td>
<td>5.8±3.2</td>
<td>5.8±3.2</td>
<td>Canine</td>
<td>Artery</td>
<td>End-end</td>
</tr>
<tr>
<td>Hasson et al., 1986</td>
<td>Continuous Prolene</td>
<td>3.2±1.1/10²</td>
<td>6.2±2.8</td>
<td>6.2±2.8</td>
<td>Canine</td>
<td>Artery</td>
<td>End-end</td>
</tr>
<tr>
<td>Ulrich et al., 1999</td>
<td>Continuous Ethicon</td>
<td>0.02 mm²/kpa</td>
<td>0.3</td>
<td>0.04-0.06</td>
<td>Pig</td>
<td>Polyurethane</td>
<td>End-end</td>
</tr>
<tr>
<td>Trubel et al., 1995</td>
<td>Continuous Prolene</td>
<td>57.38±29.3/10⁴ (LD)</td>
<td>159.52±35.4 (LD)</td>
<td>281.6±91 (LD)</td>
<td>Sheep</td>
<td>Vein</td>
<td>End-side</td>
</tr>
<tr>
<td>Trubel et al., 1995</td>
<td>Continuous Prolene</td>
<td>35.4±18.31 (AD)</td>
<td>195.81±36.2 (AD)</td>
<td>359.29±158.5 (AD)</td>
<td>Sheep</td>
<td>Mesh constricted venous</td>
<td>End-side</td>
</tr>
<tr>
<td>Tozzi et al., 2000</td>
<td>Continuous Prolene</td>
<td>68.2±37.5/10⁶ (LD)</td>
<td>66.84±19.2 (LD)</td>
<td>370.7±148.4 (LD)</td>
<td>Sheep</td>
<td>graft</td>
<td>End-end</td>
</tr>
<tr>
<td>Tozzi et al., 2000</td>
<td>Continuous Prolene</td>
<td>53.48±51.58 (AD)</td>
<td>55.89±17.6 (AD)</td>
<td>283.1±129.4 (AD)</td>
<td>Sheep</td>
<td>graft</td>
<td>End-end</td>
</tr>
<tr>
<td>Baguneid et al., 2001</td>
<td>Clips</td>
<td>4.83±0.62</td>
<td>7.28±0.67</td>
<td>6.73±0.50</td>
<td>Goat</td>
<td>Artery</td>
<td>End-end</td>
</tr>
<tr>
<td>Baguneid et al., 2001</td>
<td>Continuous Prolene</td>
<td>2.53±0.39</td>
<td>11.48±1.54</td>
<td>10.90±4.35</td>
<td>Goat</td>
<td>Artery</td>
<td>End-end</td>
</tr>
<tr>
<td>Baguneid et al., 2001</td>
<td>Interrupted Prolene</td>
<td>5.38±0.90</td>
<td>8.45±1.05</td>
<td>7.98±0.63</td>
<td>Goat</td>
<td>Artery</td>
<td>End-end</td>
</tr>
</tbody>
</table>

LD = large diameter, AD = adapted diameter, n.a. not available.
* With PHZ 1 cm to A.
† Without PHZ 1 cm to A.
‡ Compliance coefficient.
§ Cross sectional anastomotic compliance.
compliance of the anastomosis and this is awaited. Their utilisation clinically has been poor, as they require preparation of the vessels, supervised training and activation of the glues so that they set properly.

Discussion

Creation of an anastomosis affects the compliance at both the suture, clip or laser soldered site and the regions both proximal and distal to the latter. The mismatch of compliance including that of the PHZ leads to abnormal stress and strain development within the neighbouring arterial wall. This change in the vessel wall viscoelasticity alters the propagation of the haemodynamic pressure pulse waves along the length of the blood vessel. This leads to areas of flow separation and turbulence particularly at the focal point of the anastomosis generated and thus development of MIH.

Non-penetrating clips and both continuous and interrupted sutures have all been shown to produce a compliance drop at the anastomotic line and are associated with both proximal and distal PHZ. However there is less loss of compliance at the generated anastomosis with non-penetrating clips and interrupted sutures as compared to continuous sutures. However despite all the evidence, interrupted sutured anastomoses with clips as compared with conventional continuous sutures such as polypropylene. Clips are not widely used in peripheral vascular reconstructions. This is because these patients have numerous plaques and atheroma in which co-adaptation of such vessel walls may prove difficult and tedious for surgeons to perform. Greater familiarity and indeed training of surgeons in the use of automated clip anastamosing devices may perhaps encourage clinicians to use this technique for conduits and vessels with minimal to moderate disease and those patients undergoing local endarterectomy. The findings of our institution together with those of other institutions of improved para-anastomotic compliance profiles and reduced intimal damage coupled with reduced blood loss using these may increase their usage worldwide.

A possible alternative to clips may be laser-generated anastomoses with and without solder or sutures as an assist to conventional sutures or as an anastomosis on its own. The initial work demonstrated short times for generating the anastomosis and good patency, but revealed high rates of aneurysm formation and thermal damage. This problem has dramatically limited their application clinically and to date all research work has concentrated on limiting and controlling laser power so that the technique can stay in what is termed the “therapeutic window”. Further work is needed before lasers are used commonly in clinical practice.

Newer more compliant grafts have been proposed for both modalities, particularly for vascular applications. However, the polymers chosen to date have relied extensively on polyurethane chemistry with soft amorphous segments composed of ester or ether which degrade in vivo by hydrolysis and oxidation (this depending on ether content) respectively. We have been developing grafts for both applications made from poly(carbonate-urea)urethane which has shown very high resistance to degradation in vitro and in vivo and as a vascular graft is undergoing a phase I clinical trial and in use as an AV fistulae for haemodialysis. These compliant grafts may possibly lead to further improvement graft patency by reducing MIH. Furthermore work has been underway at our institution in developing fully biological “living tissue” coronary and vascular grafts where the compliance is similar to native arterial tissue, using endothelial cells, smooth muscle cells with partial scaffolds. This is known as tissue engineering and is also be another way of improving graft patency. Whilst tissue engineering is still not applicable for use in all hospitals at present, it is our hypothesis that the only way in which to maximise the clinical patency of bypass procedures is to use compliant anastomoses with viscoelastic conduits.

References


Karacagil S, Holmberg A, Narrani A, Erikkson I, Bernqvist D. Composite polytetrafluoroethylene/vein bypass
Improving the Patency of Vascular Bypass Grafts


