For more than a century, sutures have been used routinely to perform vascular anastomoses. Sutures are relatively inexpensive, reliable, readily available and they can be adapted to almost any tissue condition that may be encountered. Although patency rates of both end-to-end (ETE) and end-to-side (ETS) sutured anastomoses have increased over the past 100 years, they have not reached the perfect level of a 100%. There are a lot of factors that influence the success or failure of an anastomosis, including surgical skills to accurately place the needle and to take appropriate bites and vessel preparation and management, i.e. intima and wall manipulation, mechanical dilatation and duration of clamp application. Meanwhile, it has become clear that suturing itself also influences the fate of an anastomosis. The penetrating needle induces vascular wall damage, which in turn influences the healing process, and non-absorbable suture material is left as an intraluminal foreign body, causing an inflammatory reaction, thrombocyte aggregation, impaired endothelial function, intimal hyperplasia and hence stenosis.\(^1\)\(^-\)\(^3\)

Consequently, throughout the years, other joining techniques than suturing have been tried out, with the purpose not only to improve patency rates but also to create an easier and faster method of anastomosing. There are five main categories of non-suture anastomosing methods, including rings, clips, stents, adhesives and lasers.\(^4\) Looking at the current status of each category, including assets and liabilities, clips seem to be the most promising technique. The concept itself, however, is not new. In 600 BC, Bengal ants were used to close wounds. Their firm jaws were set at the wound edges, after which their bodies were torn off their heads. The same principle has been used to make a vascular anastomosis for the first time in the Soviet Union in 1941.\(^5\) In the next period of time, numerous modifications were introduced, but none of them gained widespread adoption as they were too cumbersome, required repeated loading and penetrated the entire vascular wall.

In the mid-1980s Kirsch et al. from the University of New Mexico, Albuquerque, NM, USA, at that time, developed a new non-penetrating method for both ETE and ETS microvascular anastomoses.\(^6\) The technique consisted of arcuate-legged clips applied to everted vessel edges in an interrupted fashion. Approval to market the device was granted by the FDA in 1993, and the device was designated the VCS clip applier system.\(^7\) It is composed of a clip applier, evertor forceps, and a clip remover. Currently, there are four clip sizes available, covering all human vessel sizes to be anastomosed. Since 1997, the system has been marketed worldwide, first by Autosuture and Tyco Health, and most recently by LeMaitre Vascular through acquisition in 2004. The latter company subsequently renamed the device ‘the AnastoClip VCS’.\(^8\) Key points in its use are proper vessel wall eversion of both vessel edges (‘no lips no clips’), manipulation and rotation with additional stay sutures, spacing and sizing of the clips, adequate serial application, full filling of each clip, and additional security checks.

Up to January 2005, a total of 72 original articles have appeared on the use of non-penetrating clips as an anastomosing technique. Eight of these reports describe the experimental use for tubular structures other than vessels, such as ureters, bile ducts, and...
nerves. With regard to vascular anastomosis, 64 papers have appeared, including 34 experimental and 30 clinical reports.

The largest clinical experience with clipped vascular constructs is with vascular access for hemodialysis. Among the reports are three prospective randomized trials. The first one is a comparison between 41 clipped and 45 sutured access procedures with prosthetic grafts. The follow-up ranged from 0 to 36 months with a mean of 17 months. Both primary and secondary patency rates, as well as flow characteristics, were similar. Although the clipped anastomoses were safe, they had no patency advantage over sutured ones in this study. In the second prospective study, 92 prosthetic grafts (50 clipped and 42 sutured) and 81 autologous fistulas (48 clipped and 33 sutured) were included over a 40-month period. There was a significant improvement in primary patency for the clipped prosthetic group at all time points studied. Additionally, there was a positive trend but no significant difference for clipped autologous fistulas. In the third prospective study, again clips were compared with running sutures during the creation of 100 consecutive radiocephalic fistulas. There were trends for a better primary and primary assisted patency with clips, but only secondary patency was significantly improved with clips. Comparatively, the numbers of included patients in these three prospective studies were relatively low. This was not the case in a large, though retrospective, multicenter trial with 1385 access procedures from 17 hospitals included in a 40-month study period. Access patencies were significantly improved in anastomoses with clips, and these differences were apparent in primary, secondary, as well as overall patency, and also with autologous fistulas as well as with prosthetic grafts. In the intention-to-treat group, primary patency at 24 months was 54% for clipped and 34% for sutured arteriovenous fistulas, and 36% for clipped and 17% for sutured prosthetic grafts. In addition, the number of interventions necessary to maintain patency was significantly fewer in clipped anastomoses.

The outcomes of these trials suggest that the use of clips results in better patency rates. The reason for this can be found in both the non-penetrating nature of the clip, but also in its interrupted character. Several reports demonstrated that the healing pattern with clips was better than that with sutures. In the acute phase, the number of inflammatory and multinucleated giant cells, and the amount of fibrin and platelet aggregation was reduced with clips. In addition, the exposure of subendothelial matrix to the blood stream was more extensive in the sutured specimens. In the longer term, the degree of intimal hyperplasia is similar or less with clips as compared to sutures. Every vascular anastomotic line displays a compliance drop, flanked by pre- and post-anastomotic hypercompliant zones that contribute to altered hemodynamics and intimal hyperplasia. Baguneid et al. showed that anastomoses with clips resulted in improved para-anastomotic compliance profiles and reduced intimal damage compared to sutures. In another series of experiments, endothelial function at the anastomotic site was studied by determination of endothelium-dependent and -independent relaxatory responses. Maximal endothelium-dependent relaxation to ADP was significantly smaller in sutured than in clipped carotid arteries, while there was no difference in maximal endothelium-independent relaxation to sodium nitrate. It was, therefore, concluded that the use of clips preserved endothelial function better than running sutures. Other assets of clips are the reduced anastomotic time and the reduced risk to the surgeon due to absence of a sharp needle.

If the results with clips are so much better, then the question arises why does not everyone uses them. I believe there are several grounds for this. First, there has been a negative report on the use of clips in carotid surgery. In that study, 16 patients with carotid endarterectomies were randomized for (primary) closure with either clips or sutures. After the operation, there were two bleeding complications in the clip group. One minor bleeding, but also a major bleeding resulting in a large neck haematoma and stroke. Therefore, the authors discouraged the use of clips for closure of carotids. Although this was a small group, and there is also another study with 100 clipped patch closures after carotid endarterectomies with only one major stroke after five years follow-up, I also believe that carotids should not be one’s first try-out. The major pitfall is the deceptively easy application of clips from the anastomotic aplier. Though the learning curve is steep, there is the real and fundamental need for symmetrical eversion and approximation with additional corner stitches and the use of evertting forceps. This requires skill, practice and training, which also gives the surgeon the opportunity to explore acceptable and unacceptable limits of the clip system.

Second, in several studies after the use of clips for atherosclerotic vessels, the results are somehow disappointing. It is difficult to get the clips attached due to an overly thickened vessel wall. A modified technique to overcome these problems has been described. In these cases, the clips were offset laterally and the vein was ‘bandaged’ over the edge of the artery, but with only three patients it is hard to draw any conclusion.

Eur J Vasc Endovasc Surg Vol 30, September 2005
from that. I personally would not recommend to use clips in overly calcified vessels, but if one would want to try nevertheless, then some surgical aspects are of special importance. In case of peripheral bypass surgery for example, I would advise to perform an oval arteriotomy, create a slightly enlarged cuff at the distal venous or prosthetic graft, and to use four mattress stay sutures at all four quadrants. In addition, take care not to use too small sized clips.

Third, liability may be the initial costs. So far, no financial data have been published. Shenoy et al.’s report initially also included information on economics, but this was expelled from publication as they were mainly derived from one single centre.10 Hospital charges and reimbursement were in favour for clips compared to sutures (data to be published).

Taken together, I believe that non-penetrating clips are a welcome supplement to the surgeon’s armamentarium. They cannot replace sutures entirely, but once the learning curve has been taken, the use of clips will lead to faster anastomatic times and improved patency rates. I would, therefore, advocate to have the clips at hand and to decide case per case whether to use the clips rather than sutures. Lastly, as vascular surgeons are always searching for more sophisticated tools to work with, this is one of them.

In conclusion, it appears that the use of non-penetrating clips provides benefits that are gradually becoming apparent in both technical and biological terms. I believe that the reluctance to actually apply clips will reduce as surgeons are increasingly trained with the use of the device. After gaining experience with clips in relatively healthy vessels (such as with access surgery), the surgeon can expand indications for clip application in other conditions. So far, best successes have been achieved with microvascular tissue transfers, vascular access surgery and transplantation surgery, but clips can be used in any vascular reconstruction with relatively healthy vessels. Obviously, this is also their greatest limitation. Finally, future considerations may include the use of clips through minimally invasive access sites or even laparoscopically, the expanding use for microscopic neurorrhaphy, spinal dural closure and bile duct repair in the clinical setting, and a new attempt to develop a one-shot device.

References


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