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A New Technical Approach for Sternal Closure with Suture Anchors (Dogan Technique)

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ABSTRACT

Objectives: Various methods for sternal approximation have been described previously. Some patients undergoing these procedures are at risk for sternal dehiscence and mediastinitis. We used a different method, with a suture anchor system, for median sternotomy closure as an alternate technique in patients with a high risk of postoperative sternal dehiscence and sternal nonunion.

Material and Method: Suture anchor systems have been developed principally for the fixation of tendons or ligaments to the bone. We first used the suture anchor system for median sternotomy closure, although it has been frequently used in various orthopedic surgical procedures. In this report, we describe the use, after fresh cadaveric tests, of an alternative technique in a patient undergoing coronary artery bypass grafting.

Results: There were no complications due to the suture anchor device, and successful application was performed for sternotomy fixation after surgical procedure in a patient. The standard techniques have several disadvantages, such as osteomyelitis, chondritis, cutting into the sternum and sternal dehiscence, prolonged hospitalization, and increased mortality and morbidity due to the listed complications, but these devices may protect the wire from cutting into the sternal bone.

Conclusion: We propose suture anchors for reapproximation of the sternum to decrease the complications related to surgical steel wires. We therefore consider this technique to be easy, safe, and effective in patients with diabetes mellitus or severe osteoporosis considered to have risk for sternal dehiscence postoperatively. Another advantage of this suture system is that the titanium wire makes it more magnetic resonance compatible than systems using surgical steel wire.

INTRODUCTION

The sternum is generally reapproximated with 5 to 6 stainless steel surgical wires during surgery. This procedure can result in complications such as induration due to local allergic reactions and extreme irritation caused by the wire, resulting in patient discomfort. Under these circumstances the wire must be removed. Another clinical problem is chest pain occurring when the patient is in the lateral decubitis position. Many techniques for sternal reapproximation have been described, including various wiring configurations, mersilene tapes, and nylon bands. For the most part, surgeon preferences are based on clinical experience rather than scientific analysis. Recently, rigid internal fixation with specially designed hardware has been described and recommended, but it has not become popular in cardiac surgery because of the increased time required for sternal fixation. Optimal sternal wound healing is the result of many different factors such as the type of surgical procedure, and patient characteristics such as positive smoking history, obesity, diabetes, and prior sternotomy increase the incidence of wound complications. Although the wire method is widely used, complications related to sternal nonunion or malunion can lead to hardware failure, incisional pain caused by sternal motion, reoperation, infection, sepsis, and, occasionally, death. Because of use of electrocautery, there is a risk of ventricular fibrillation during revision surgery if the wires are near the myocardium .

Suture anchors have been frequently used in orthopedic procedures. These are principally used for the fixation of tendons or ligaments to the bone. We describe a different approach for sternal closure. We believe that the iatrogenic injury of mammary or intercostal vessels can be avoided with this technique.

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TECHNIQUE

Basic Principles for Application of Suture Anchors

There are several suture anchors available on the market, such as Mitek (Mitek Surgical Products, Norwood, MI, USA), Linvatec Revo screw (Linvatec, Largo, FL, USA), Acufex Tag Wedge (Acufex Microsurgical, Mansfield, MA, USA), Statak (Zimmer, Warsaw, IN, USA). We prefer Statak suture anchors because of anchor size and holding strength.

The soft tissue attachment device consists of a suture anchor with an attached suture assembled to a driver. This device is designed to permit efficient reattachment of the soft tissue to bone. Attachment is secured by anchoring the suture within cortical or cancellous bone. Each of the 2 free ends of

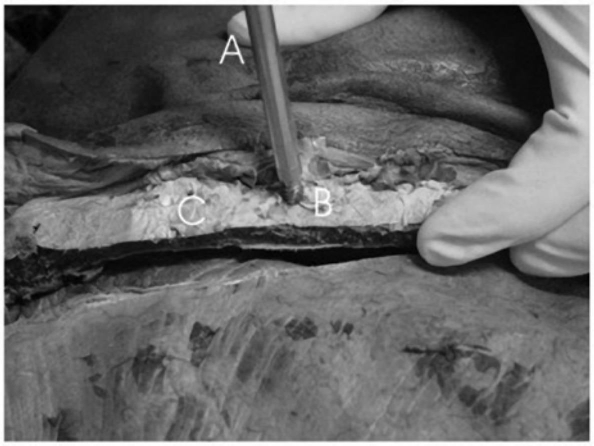

Figure 1. Insertion of the suture anchors with help of the drill bit with angle settled down to the manubrium of the cadaveric sternum. A, Drill bit; B, suture anchor; C, sternum.

Figure 3. Two free 0/0 Ethibond suture ends in circular suturing from both of the sternal borders, soon to be tied up and reapproximated.

anchored suture is then loaded through the eyelet of a curved free needle. The following surgical technique is designed for Statak suture anchors.

The suture anchor is a self-drilling, self-tapping threaded device. A doubled-strand, braided suture is looped through the eyelet of the anchor. A driver delivers the suture anchor to the desired depth of the bone. The driver is then removed and discarded. Various size anchors are provided for utility, corresponding to the anatomic size requirements.

The Statak soft tissue attachment device assembly is inserted into the Jacob's chuck of the drill. The drill point of the Statak assembly is placed through the cannula at the desired point of implantation. Pressure is applied to the drill to begin. While pressure is continually applied to the assembly at the implantation site, drilling is begun. When the shoulder of the driver makes contact with the bone cortex and no longer advances, the driver is turned 2 to 5 turns

Figure 2. The metallic part of the device withdrawing from the tubular part of the device after application.

before drilling is stopped. The anchor will automatically disassociate from the driver assembly. The drill, with the driver in place, is pulled away from site. The suture will disengage from the cap, and the driver may be discarded. Excess suture is trimmed after being hand tied.

We first studied the proposed technique on 2 fresh cadavers. We performed sternotomies after making a standard midline incision. We inserted the first and second suture anchors (Statak, 5 mm) with the drill bit; the angle settled down to the manubrium of sternum, and we implanted the devices on the manubrium approximately 20 mm lateral to the sternotomy line (Figure 1). Then the metallic part is withdrawn from device with the drill bit (Figure 2). After that, the third and fourth devices were inserted into the body of the sternum with the aid of the drill bit. Two free 0/0 Ethibond sutures were attached to the anchor, and these were passed through the sternum ipsilaterally outside-inside with a needle, and inside-out on the contralateral hemisternum (Figure 3). After that application, the free suture ends were then tied up and reapproximation was achieved with 0/0 Ethibond suture (Figure 4). Figure 5 shows a graphic representation of the suture anchor in place. On the cadavers, 5 of the suture anchors were inserted, and after stretching the sutures it was noted that no movement or sliding was observed through application of a 70-kg force. After the closure of the sternum, novel and mechanical forces were again applied, and no instability was detected (the applied force was approximately 70-80 kg). Maximal sternal stability was achieved in both the vertical and transverse axes of the upper and lower sternum.

After cadaveric tests were performed, we applied this technique in a coronary bypass surgery patient (Figure 6). During this patient's surgery we inserted 5 suture anchors as described. Good stability of the sternum was achieved (Figure 7). No complications were seen during the postoperative period. The patient was discharged from the hospital on the seventh day, and 1 year after surgery we did not see any complications due to the suture anchor system.

Figure 4. The suture anchors are inserted to the bone, and the Ethibond sutures are knotted.

Figure 6. Insertion of 5 suture anchors in a coronary artery bypass patient.

We therefore considered this technique easy, safe, and also effective in patients considered at risk for sternal dehiscence.

DISCUSSION

Median sternotomy is one of the most widely used approaches for surgery involving the heart and great vessels. Various methods for sternal approximation have been described previously. Some of the patients are under risk of sternal dehiscence and mediastinitis. There is still no consensus among surgeons on the optimal method for sternal closure. Many techniques have been described, including various wiring configurations, mersilene tapes, and nylon bands. For the most part, surgeon preferences are based on clinical experience rather than scientific analysis [Sirivelle 1987, Hendrichsen 1996, Ozaki 1998]. Dasika et al [2003] have shown that there are no mechanical differences between simple wires and figure-eight wires. However, many surgeons believe that figure-eight wires provide better sternal stability. Recently, rigid internal fixation with specially designed hardware has been described and recommended, but it has not been popular in cardiac surgery because of the increased time required for sternal fixation [Hendrichsen 1996]. Optimal sternal wound healing is the result of many different factors such as activity of surgical procedure, and patient characteristics such as history of smoking, obesity, diabetes, and prior sternotomy increase the incidence of wound complications. Cohen and colleagues have demonstrated 25% improvement in resistance to failure with the use of pectofix dynamic sternal fixation stainless steel plates in their study comparing 3 sternotomy closure techniques [Cohen 2002]. Although the wire method

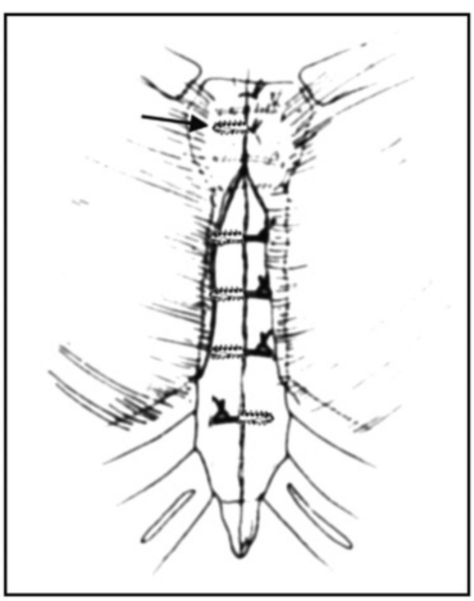

Figure 5. Graphic representation of the suture anchor system.

Figure 7. Appearance of the sternum after application of the devices in the coronary artery bypass patient.

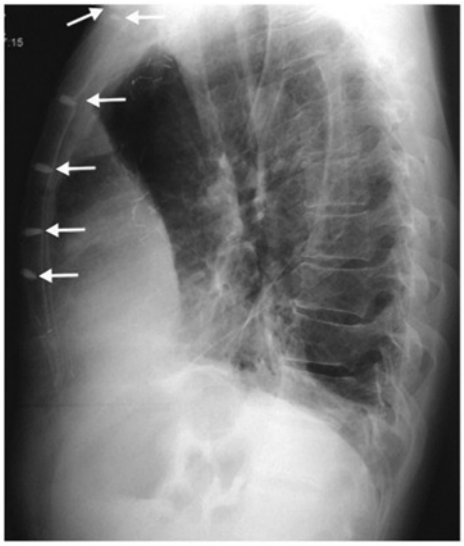

Figure 8. Postoperative day 7 lateral chest x-ray film of the patient. Arrows indicate the Statak suture (device size is 5 mm) in the sternum.

is widely used, complications related to sternal nonunion or malunion can lead to hardware failure, incisional pain caused by sternal motion, reoperation, infection, sepsis, and occasionally death [Serry 1980, Bitkover 1998, McGregor 1999]. Clinically, an unsuccessful result usually involves the wire cutting into the bone [Campo 1982]. This complication produces a separation of the sternum, which can result in a nonunion and other complications such as mediastinitis. Poor sternal healing leading to sternal separation, and dehiscence after sternotomy is a significant complication that occurs in 0.5% to 2.5% of cases [Tavilla 1991, Stahle 1997]. Sternal dehiscence may cause patient discomfort, mediastinitis, osteomyelitis, and chronic sternal instability, and it is associated with a 10% to 40% mortality rate [Tavilla 1991, Goldman 1998]. The sternum is generally reapproximated with 5 to 6 stainless steel surgical wires during surgery. Complications can be summarized as induration due to local allergic reactions and extreme irritation caused by the wire, resulting in patient discomfort. Under these circumstances the wire must be removed. Another clinical problem is chest pain occurring in lateral decubitis position, which is seen in approximately 2% to 3% of our patients. There is a risk of ventricular fibrillation due to use of electrocautery during revision surgery if the wires are near the myocardium. The wires are passed all around the sternum except for the manubrium where they are passed through the bone. The iatrogenic injury of mammary or intercostal vessels can be avoided with this described technique. Suture anchors have been frequently used in orthopedic procedures. These are principally used for the fixation of tendons or ligaments to the bone.

Puc et al [2000] reported that a reduction in tissue damage occurred during 10 years of experience with the use of mersilene tape. In another 2 studies [Johnson 1985, Sirivella 1987] mersilene tape was found to be extremely beneficial. Negri et al [2002] have reported superior results in sternal osteosynthesis following sternal closure with use of thermal shape-memory Nitillium clips, and clinical benefits of Nitillium clips are discussed in their report. They suggest that thermoreactive Nitillium clip (TRNC) devices are beneficial because of their favorable properties such as elasticity and geometry. These authors reported the use of 2 or 3 wires (to the upper and lower parts of the sternum) along with techniques such as mersilene tape and TRNC. Using our technique in fresh cadaveric tests and a coronary artery bypass graft patient, we obtained enough sternal stability and did not require the additional use of surgical steel wire for sternal closure.

Even though sternal wire initially gives a stronger repair, this increased tension can potentially tear through the sternum, and it can cut the sternum into multiple fragments.

Suture anchoring provides an alternative when closing a sternal incision in patients with the potential for major complications, especially patients with risk factors for developing sternal wound complications, such as diabetes mellitus, osteoporosis, long intubation time, and reoperation. Also, this device may be used in patients with sternal nonunion or malunion. According to the literature, preoperative risk factors for sternal wound complications include obesity, diabetes mellitus, chronic obstructive lung disease, renal insufficiency, advanced age, osteoporosis, and positive smoking history [Ottino 1987, Blanchard 1995, PMSG 1996]. Asymmetrical sternal section, bilateral internal thoracic artery harvesting, and improper sternal closure are other risk factors of sternal wound complications postoperatively.

Because this device uses 0/0 Ethibond suture, the suture anchor may decrease the incidence of superficial wound infection and/or sternal aseptic necrosis because it does not require circular closing of the sternum with wire. The 0/0 Ethibond suture material is compatible with computed tomography scans and magnetic resonance imaging (MRI). It also may be used in patients with mechanical sternal dehiscence and need for sternal reconstruction. Suture anchors have been frequently used in orthopedic procedures. These are principally used for the fixation of tendons or ligaments to bone [Barber 1995]. However, suture anchors are used for fixation of bones in selected clinical situations. One of the authors described a technique for fixation of bones with suture anchors instead of using screws during distal metatarsal osteotomies in patients with hallux valgus. He did not mention any problem with the use of suture anchors such as delayed union, malunion, implant failure, or local reaction [Oznur 2002]. Sternotomy fixation with standard techniques has several disadvantages such as osteomyelitis, chondritis, sternal dehiscence, prolonged hospitalization, and increased mortality and morbidity due to the listed complications [Ottino 1987]. Patients with diabetes mellitus, lung disease, obesity, malnutrition, or osteoporosis are at greatest risk of sternal wound complications [Scovotti 1991]. The incidence of major wound complications has been reported as 0.7% to 1.9%, with a mortality rate of 10.3% to 39.6% [Tavilla 1991]. Several techniques have been described for sternal closure following sternotomy [Robicsek 1977]. During reapproximation, because the sternum wire is rotated around itself, the twisted portion can perforate the subcutaneous and cutaneous tissues. This irritation does not occur with techniques using suture anchor fixation because reapproximation is achieved with Ethibond sutures. The screw of the anchor is also buried into the intramedullary cavity of the sternum. Injury from fracture or migration of sternal wire is a rare but potentially devastating complication of median sternotomy. Schreffler et al [2001] reported a case of an intravascular migration of a fractured sternal wire presenting with hemoptysis. Barber et al compared the suture anchors currently available in terms of modes of failure, ultimate failure strengths, and implant security. Statak suture anchors (5.0 mm) had the highest mean failure strength in cancellous bone compared to other suture anchors in this study. This suture anchor (Statak 5.0 mm) had significantly better pullout strength, which was 237 pounds [Barber 1995]. We recommend 5-mm Statak suture anchors, which according to this biomechanical study cannot penetrate the posterior aspect of the sternum. During reoperations cutting and removing wires is quite difficult and takes quite lot of time. Because these suture anchors consisted of Ethibond sutures, they can be very easily and quickly removed, especially in the emergency revisions. Because of their intramedullary localizations the suture anchors do not transfer electricity, so it is much safer to use electrocautery in reoperations on patients at risk for ventricular fibrillation. These suture anchors are MRI-compatible medical devices. We have used the Statak suture anchors for sternal closure in a coronary artery bypass graft patient. We did not observe any complications related to sternal closure when this technique was employed. This modification increased the early postoperative comfort of the patient and satisfaction from surgery. However, the additional cost to the patients of suture anchors should be taken into account. This technique is recommended for patients who have severe osteoporosis and metabolic bone disease because it causes no damage from tension in the weak bone. We assume that some of complications such as infection, irritation, and wound problems during sternal closure would be decreased with this modified technique.

In summary, especially in cases in which invasive conventional radiological techniques are contraindicated and in cases for which an MRI follow-up is needed, the suture anchor system is an alternative to the surgical steel wire because it is made of titanium, and will produce much better results considering that the surgical steel wire would interfere with MRI imaging. Because of the previously mentioned benefits, this newly developed technique is convenient for the surgeon closing the sternotomy.

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