Use of Bioabsorbable Plates for Cranial Fixation
—Technical Note—

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Abstract

LactoSorb® fixation plates are made of a bioabsorbable polymer (82% poly-L-lactic acid and 18% polyglycolic acid), and the strength is not inferior to titanium plates. LactoSorb® has been used in the fields of pediatric neurosurgery and facial plastic surgery. Cranial fixation in craniotomy is mostly performed using titanium plates and clamps, but there are issues with esthetics and artifacts on postoperative radiographic images. Absorbable plates solve these problems, but are slightly thicker and more expensive. Here, we describe a technique to solve these disadvantages by inserting absorbable plates into the diploe. The present method was employed in 46 patients, and esthetically favorable results were obtained without intraoperative and postoperative complications. Absorbable plates may replace titanium plates as the main device for cranial fixation. The present method is particularly useful for cranial fixation in adults with a thin scalp.

Key words: cranioplasty, bioabsorbable plate, fixation, polymer

Introduction

Cranial fixation using silk and cotton sutures was performed as early as the second half of the 19th century. However, the weak fixation strength resulted in common complications including cranial flap displacement,10) so metal plates have been used since the middle of the 20th century, especially the recent adoption of titanium plates and clamps.3,5,9)

Recently, interest in the esthetic outcome of neurosurgery has increased, and psychological suffering due to protruding plates can no longer be ignored. Metal plates protrude more in the lateral direction than sutures, and protrusion is noticeable in patients with thin scalp even using thin mini plates. In fact, patients with a thick scalp may suffer psychologically if the plates are palpable. Skin inflammation at the area of protrusion can lead to ulcer formation,9) and complications may require surgical removal.21) Furthermore, the metal plates may cause artifacts on postoperative radiographic images, making postoperative follow up more difficult. Absorbable plates have been used in pediatric neurosurgery and facial plastic surgery,1,2) but not often for cranial fixation in adults. The biggest reason is the poor cost performance and concerns for weak fixation strength.

Here, we describe a new cranial fixation method using absorbable plates (LactoSorb®; Biomet Microfixation, Inc., Jacksonville, Fla., U.S.A.).

Surgical Technique

The patient is placed in the supine position, and the head is rotated to the contralateral side and immobilized. Frontotemporal craniotomy is performed by forming a two-layer skin flap. Loose areolar tissue is left behind on the periosteal side to reinforce the fragile periosteum in the frontal region. The temporal muscle is detached immediately above the fascia and reflected. The periosteum is cut along a line different from the osteotomy line, detached as a pedicle graft, and then conserved. No incision is placed in the temporal muscle. The temporal muscle is detached with the periosteum using a raspatorium, and is reflected in the posteroinferior direction. Without the so-called key hole, burr holes are made in the pterion, squamosal suture, and coronal suture, and the cranium is opened. The sphenoid ridge
Fig. 1 Operative photographs showing craniotomy with fixation by the present method. A: Side holes were made with a Linderman burr attached to a Primado® (contra-angle attachment, Nakanishi Inc.) in the frontal, parietal, and temporal regions. B: LactoSorb® plate was inserted. C: First, a side hole was made in the frontal diploe. Caution must be exercised to properly align the hole, and to avoid opening the frontal sinus. D: Then, a side hole was made in the parietal region, and widened in the posterior direction in order to slide the bone flap. E: The outer plate in the temporal side was shaved thinly. F: Absorbable screw was placed after drilling for fixation.

Fig. 2 Cranial fixation using LactoSorb® after a craniotomy to allow aneurysm clipping. A: Three-dimensional computed tomography scans showing favorable bone flap fixation without flap displacement. No metal plates were used. Burr holes were covered with the internal plate fragments harvested during craniotomy or burr hole caps made of ceramic artificial bone. Smooth bone-to-bone union was achieved in the most notable area from the frontal region to the pterion region. B: Photographs taken 3 months after surgery. Displacement was not seen at the craniotomy site, and there were no esthetic issues.

Fig. 3 Illustrations of the three main methods of fixation. A: Three plates with 4 straight holes and six 1.5-mm screws (thick arrows) are used to fix a bone flap from outside the cranium. B: The present method uses three plates with 4 straight holes and a single 1.5-mm screw (thick arrow) for fixation. C: Conventional fixation using three titanium plates and 12 screws (arrows).

is cut at the base and replaced after the end of craniotomy.

After the intracranial procedures, a hole with a width of 5 mm and depth of 1 mm, matching the size of the absorbable plate, is made in the diploe of the free bone flap, and absorbable plates are inserted into the frontal, parietal, and temporal regions. A Linderman burr attached to a Primado® (contra-angle attachment, Nakanishi Inc., Kanuma, Tochigi) was used to form the side holes (Fig. 1A). The holes could be expanded sideways, and easily matched to the size of the LactoSorb® plates (Fig. 1B, C). Each hole could be made in about one minute, and bone flap fixation took about 10 minutes, similar to the surgical time to fix the bone flap using titanium plates. The same procedure is performed on the corresponding frontal region and the cranial side of the parietal region, so that the bone flap can be supported in a straight hairpin fashion. The cranium is thin in the temporal region, so caution was necessary when making side holes into the diploe. The outer plate was shaved and the plate was then fixed using a screw in the posterior temporal region where the bone was particularly thin. Therefore, there was no need to make a side hole in the temporal region, and this was easy to perform (Fig. 1D–F).

At this stage, preoperative investigations are needed in the frontal region to avoid making holes in the frontal sinus. The bone flap can be slid into position in the parietal region by making the width of the hole larger in the posterior direction (Fig. 1). Finally,
the temporal side is fixed. The bone flap cannot be slid into the correct position if the plate is inserted in all three regions. Therefore, a groove is made on the outer plate of the temporal region using a drill, so that the bone flap surface matches the lateral cranial surface. The plate is then fixed using a single absorbable screw to complete cranial fixation. The temporal muscle is then returned to its original position, and the peritoneum is sutured to completely cover the bone flap. Surgery is completed by closing the skin flap.

This technique was employed in 46 patients (mean age 58 years) who underwent scheduled frontotemporal and frontal craniotomy from October 2007 to September 2008. Surgery was performed for unruptured cerebral aneurysm in 41 patients, internal carotid artery stenosis in 3 patients, moyamoya disease in 1 patient, and pituitary adenoma in 1 patient. The length of follow-up observation ranged from 10 to 362 days (mean 170 days). Side holes were formed as planned in all patients, and no iatrogenic complications such as damaged dura occurred. No postoperative infection, abnormal granulation, cranial deformation, or displacement was seen (Fig. 2).

The reimbursement price for fixation using titanium plates (Fig. 3C) is 134,340 yen, and that for the present method (Fig. 3B) is 165,000 yen. The reimbursement price for fixation using LactoSorb® plates placed on the cranium (Fig. 3A) is 349,500 yen. Therefore, the present method is cost effective, as well as esthetically acceptable.

Discussion

LactoSorb® is made of a bioabsorbable polymer (82% poly-L-lactic acid and 18% polyglycolic acid), and the strength is comparable to that of titanium plates.6) The plate has a rail shape, and the thickness of the rail region is 0.9 mm, and the inter-rail region is 0.5 mm. Therefore, LactoSorb® is slightly thicker than titanium plates. LactoSorb® retains about 70% of its initial strength at 2 months after surgery, and it is completely absorbed within 12 months, whereas adequate bone union can be achieved within 2 months of surgery.7) Therefore, sufficient strength is maintained during the period when fixation is required, and the LactoSorb® is then absorbed. LactoSorb® does not cause any problems in postoperative radiographic imaging.

Although LactoSorb® is a superior fixation device, its thickness and high cost have prevented its use in routine surgery. With the present cranial fixation method, LactoSorb® plates are inserted like straight hairpins by making side holes in the frontal and parietal regions where plates can cause esthetic problems, resulting in no unevenness on the bone surface. No postoperative displacement was seen in any of our 46 patients. Internal fixation was performed by placing metal pins into the diploe in 50 patients, and no complications occurred.9) The present method is cost effective because only one screw is used.

For instance, when part of temporal bone is taken away to extend the bone window, it is likely to become disadvantageous. Because LactoSorb® cannot cover the defective part. In such case, the bone dust will be provided to bury the defective part. And if it is difficult to use our method for the large defective part or thinness of the skull, the straight plate can be used to fix the bone flap from outside. Fortunately, we do not have such an experience.

Fixation methods without metal plates include techniques to crosslink bone flaps using a T-saw or thin chisel, and techniques to fix bone flaps using small fragments collected from the inner plate of the bone flap as wedges.4,8,10) These techniques are also cost effective, provide high fixation strength, and do not affect postoperative radiographic imaging. However, these procedures are somewhat complex, and require skill and experience.

The present method formed side holes which could be widened sideways to match the size of the LactoSorb® plates. Better esthetic outcomes were ensured by preoperatively designing the bone flaps using crystal violet and eliminating gaps in the frontal region that cause postoperative problems. The present method is easy to perform, and takes a comparable amount of time to bone flap fixation using titanium plates.

As the safety of neurosurgery has improved, the demand for less invasive surgery has increased. Therefore, we believe that absorbable plates will replace titanium plates as the primary tool in cranial fixation. The present method is useful for cranial fixation in adults, particularly those with a thin scalp.

References

3) Lerch KD: Reliability of cranial flap fixation techniques: comparative experimental evaluation of...


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Commentary

The authors described a new technique of employing bioabsorbable miniplates and screws for cranial osteosynthesis. Although it seems to be a time-consuming technique, the authors claim otherwise. Bioabsorbable implants have been used extensively in medicine, mainly in cranio-facial surgery. Experience with these implants has demonstrated less implant morbidity with additional advantage of being radiolucent. Disadvantages include weakness relative to metal implants, rapid loss of initial implant strength, and foreign body reactions, besides of the higher costs. The minor complications consist mainly of infections, dehiscence of the wound and plate exposure together with granulation tissue in the operation field. In neurosurgery, they have been utilized mainly in pediatric surgery. We think they represent an advance compared with metal implants, however their costs and the complexity of the procedure described in this paper constitute obvious drawbacks. Indeed, as technology advances and costs reduce, their widespread use and acceptance may dramatically increase.

Ebeval G. Figueiredo, M.D.

Modern neurosurgery requires more cosmetic improvements after the surgery. The authors reported a new method to fix the cranial bone flap using bioabsorbable plates. The key point of this technique is the formation of side holes in the diploe of the free bone flap and cranial edge. The bioabsorbable plates are inserted into the side holes for fixation. Therefore, the plates are hidden from the cranial surface. The authors confirmed this fixation method did not show any displacement and was esthetically favorable. They also reduced the medical cost of this internal fixation system by minimizing the number of the plates and screws. Although the follow up period was relatively short, I agree that this method succeeded in bone flap fixation without any protrusion on the surface. However, favorable cosmetic results cannot be achieved only by the reconstruction of the smooth cranial surface. Once the temporal muscle is dissected from the cranium, its atrophy must be avoided. This atrophy causes flattening of the outline of the face in the temporal region, the so-called “temporal halo.” Without solving this problem, the complete esthetic satisfaction of the patients cannot be obtained.

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This is an interesting technical note by Noda et al. describing fixation of the bone flap to the skull using an absorbable plating system. From their illustrations this appears to be a simple and cost-effective system and does not take more time than the titanium plating that is commonly performed. There is, however, a situation that could pose a problem. Although the authors have never encountered such a situation, at times a significant gap occurs between the edge of the skull and the bone flap. Unless this gap is filled with a mesh or a larger plate, the absorbable plate system will not prevent the bone flap from sliding and an unsightly indentation of the scalp will occur. I wonder how the authors would deal with that. The authors have described a useful technique that will be especially useful in patients with a thin scalp where the titanium miniplates would be visible and even have a tendency to erode through the skin.

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