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Clinical Study

Free craniotomy versus osteoplastic craniotomy, assessment of flap viability using 99mTC MDP SPECT

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ABSTRACT

There are currently two accepted neurosurgical methods to perform a bony flap. In an osteoplastic flap, the flap is attached to surrounding muscle. In a free flap, the flap is not attached to adjacent tissues. The former is less common due to its complexity and the extensive time required for the surgery; yet the rate of infection is significantly lower, a clear explanation for which is unknown. The objective of this study was to test the hypothesis that the osteoplastic flap acts as a live implant that resumes its blood flow and metabolic activity; contrasting with the free flap, which does not have sufficient blood flow, and therefore acts as a foreign body. Seven patients who underwent craniotomy with osteoplastic flaps and five with free flaps had planar bone and single photon emission computed tomography (SPECT) scans of the skull at 3–7 days postoperative, after injection of the radioisotope, 99m-technetium-methylene diphosphonate (99m-Tc-MDP). We compared radioactive uptake as a measure of metabolic activity between osteoplastic and free flaps. Mean normalized radioactive uptakes in the centers of the flaps, calculated as the ratios of uptakes in the flap centers to uptakes in normal contralateral bone, were [mean: 1.7 (SD: 0.8)] and [0.6 (0.1)] for the osteoplastic and free flap groups respectively and were [2.4 (0.8)] and [1.3 (0.4)] in the borders of the flaps. Our analyses suggest that in craniotomy, the use of an osteoplastic flap, in contrast to free flap, retains bone viability.

1. Introduction

The skull is a membranous structure comprised of two cortical bone layers separated by diploic bone. Skull bones are formed by both intramembranous and endochondral ossification, and their viability depends on blood flow to the region. In 1889, Wagner developed the craniotomy using a bone flap that remained attached to the surrounding temporal muscles [1]. In 1912, Leriche developed the free bone flap craniotomy [2]. Osteoplastic flap is less frequently used than the free flap, due to the greater complexity and time required for the surgery. Nevertheless, the rate of infection has been reported as significantly lower for the osteoplastic than for the free flap [3–5]. To our knowledge, there is no clear explanation for this.

Bone scan using radioactive isotopes is an accepted means of evaluating bone metabolism. The use of isotope with single photon emission computed tomography (SPECT) allows tomographic pictures with high resolution of the bone and relatively low background noise. Bone uptake of a radioactive marker, most commonly 99m-technetium-methylene diphosphonate (99m-Tc-MDP), is dependent on the number of vessels feeding the organ and on the osteoplastic activity. Consequently, bone scan can be used to measure the viability of a bony flap.

The objective of this study was to test the hypothesis that an osteoplastic flap retains metabolic activity of the bone, as assessed by bone scan; and that a free flap, in contrast, is characterized by decreased metabolic activity of the bone.

2. Materials and methods

Metabolic activity, as assessed by bone scan, was compared between seven patients who underwent a craniotomy using the osteoplastic flap and five who underwent procedures with free flaps.

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2.1. Surgical method

The patient positioning, skin incision and cutaneous flap were of standard pterional craniotomy and were identical in both methods. The free flap involved subperiosteal dissection and detachment of the temporal is muscle and the periosteum from the skull. During the surgery, the bone was moved away from the operating field and wrapped in sterile pads soaked in normal saline. At the end of the procedure the bone flap was attached back into place using microplates. The temporal muscle was sutured along its cut edges leaving it detached from the bone.

In the osteoplastic flap the temporal is muscle was not dissected from the bone. The base of the bone window was cut from inside out using a thin Gigli saw (Aesculap, Tuttlingen, Germany), allowing the periosteum and surrounding muscle to remain undamaged and attached to the flap (Fig. 1). At the end of the surgery, the bone was attached back into place while still connected to the muscle.

2.2. Scanning procedure

All patients underwent planar bone and SPECT scans of the skull to evaluate bone viability 3–7 days post-surgery. Three stages are involved in performing a bone scan. The first assesses blood flow to the region of interest (ROI). Following intravenous injection of 20–25 mCi of 99m-Tc-MDP, images are taken quickly. At this stage, changes in blood flow may signify circulatory insufficiency to the bone early on. In the second stage, referred to as the pooling stage, samples of blood pooling in the ROI are documented by images taken every 5 minutes. This measurement represents blood pooling in the capillaries. In the third and final stage we measured bone uptake of 99m-Tc-MDP, 2-3 hours after its injection (Fig. 2). This indicates metabolic activity and blood circulation in the bone. Planar scans used a format of 256×256 pixels with 300,000 counts per picture. The SPECT scan used a format of 128×128 pixels, 120 pictures with each picture containing 60–80,000 counts. Scans were constructed using am Varicam double-head camera (General Electric Medical Systems, Haifa, Israel) with VPC 40 collimator (General Electric Medical Systems), low energy, and high resolution, connected to the Expert processing station (General Electric Medical Systems).

2.3. Assessment of bone viability

The ROI was placed on three-dimensional (3D) projection over the center of the flap, border of the flap and normal contralateral side (Fig. 2). Average counts per pixel at the ROIs were compared to the normal contralateral bone and normalized ratios of bone activity were calculated: counts over the flap center (center counts)/normal contralateral side counts and counts over flap border (border counts)/normal contralateral side counts. Ratios of osteoplastic to free flaps, for normalized flap center and border counts were calculated. A simple Student's *t*-test was used to compare between groups.

3. Results

Five men and two women underwent procedures with an osteoplastic flap, [mean age: 51 year (SD: 18 years)]. Four men and one woman underwent a free flap, [mean age: 66 (SD: 9 years)]. All patients underwent craniotomy for a brain metastasis, except for one in the free flap group, who had a subdural hematoma caused by a metastasis. The mean interval between surgery and imaging was 10 days (standard deviation [SD] 4 days) for the osteoplastic flaps and 8 days (SD 4 days) for the free flaps. Mean normalized radioactive uptakes in the flap centers, calculated as the ratios of uptakes in the flap centers to uptakes in normal contralateral bone, were 1.7 (SD 0.8) and 0.6 (SD 0.1) for the osteoplastic and free flap groups respectively ($p < 0.001$). Mean normalized radioactive uptakes in the flap borders, calculated as the ratios of uptakes in the flap borders to uptakes in normal bone, were 2.4 (SD 0.8) and 1.3 (SD 0.4), respectively ($p < 0.01$). The ratio of the normalized uptake in the osteoplastic relative to free flap center was 2.8. (Table 1) The ratio of the respective normalized borders was 1.9. (Table 1). One patient in the osteoplastic group experienced severe brain edema following tumor resection 3 weeks after the initial procedure. He was taken back to the operating theatre for decompressive craniectomy. Pathological examination of his temporal bone revealed signs of new bone formation, which was indicative of healing within the bone (Fig. 3). Six months after the surgery none of the patients in either group suffered bone flap infection. The cosmetic result was better in the osteoplastic group in terms of symmetrical temporal is muscle and was associated with better mouth opening.

4. Discussion

Osteoplastic craniotomy flap is a well-established surgical method in many neurosurgical centers. Despite the greater operating time, this technique carries less risk of complications than the free flap method [3–5]. In this study we demonstrated that keeping

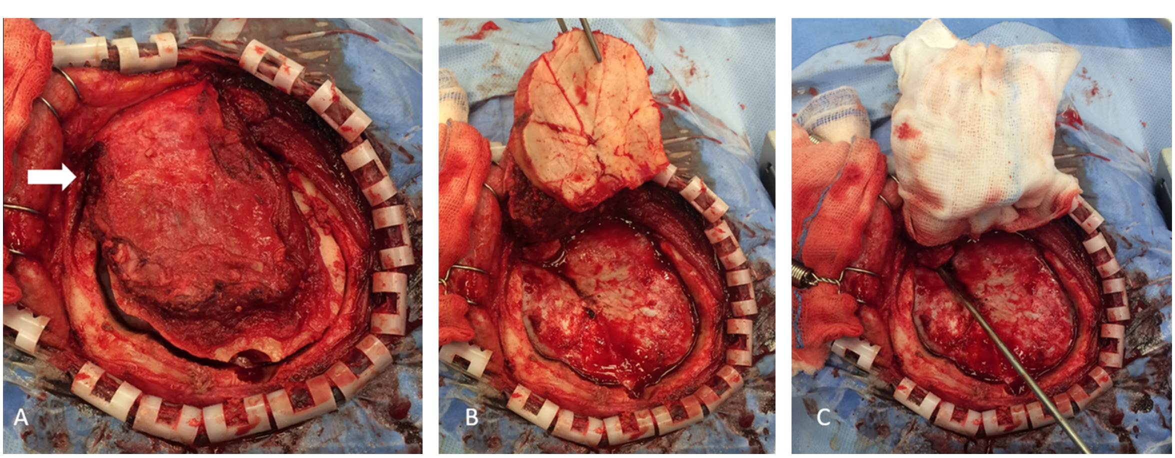

Fig. 1. Osteoplastic flap technique. (A) Craniotomy performed while the muscle is attached to the bone. The arrow indicates the keyhole point, (B) the bone is attached to the muscle and retracted together with it and does not limit the extent of retraction, (C) during the resection the flap is maintained in a wet gauze together with the temporalis muscle.