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# Bone flap management in neurosurgery

Manejo do flap ósseo em neurocirurgia

Andrei Fernandes Joaquim<sup>1</sup>, João Paulo Mattos<sup>2</sup>, Feres Chaddad Neto<sup>3</sup>, Armando Lopes<sup>4</sup>, Evandro de Oliveira<sup>5</sup>

## RESUMO

A remoção cirúrgica do flap ósseo em casos de craniotomia descompressiva vem sendo cada vez mais usada para o tratamento de swelling pós-traumático, doenças cerebrovasculares ou no edema cerebral pós cirurgia eletiva não responsivo ao tratamento clínico. O destino do retalho ósseo até ao seu uso para cranioplastia em tempo oportuno é motivo de controvérsia e diferentes condutas são adotadas em centros de todo o mundo. Abordamos e discutimos nesta revisão os diferentes locais de preservação do retalho ósseo (subgaleal, parede abdominal e congelamento), quando desprezá-lo e o que fazer frente à contaminação durante o ato operatório ou se infectado.

Unitermos. Neurocirurgia, Procedimentos Neurocirúrgicos, Craniotomia.

Citation. Joaquim AF, Mattos JP, Chaddad-Neto F, Lopes A, Oliveira E. Manejo do flap ósseo em neurocirurgia Rev Neurocienc, in press.

## SUMMARY

Bone flap removal procedure is growing in frequency in neurosurgical practice. Decompressive craniotomy has gained more scientific evidences of its therapeutical value in post-traumatic brain swelling, in cerebrovascular diseases and in brain edema non-responding to clinical treatment after elective surgeries. Bone flap destination after craniotomy has many possible fates. We present a literature review of bone flap management in neurosurgical practice: technical preservation of bone flaps (under the scalp, in the abdominal wall, frozen), when to remove the bone flap and what to do when it is dropped during the craniotomy or is infected.

Keywords. Neurosurgery, Neurosurgical Procedures, Craniotomy.

Citation. Joaquim AF, Mattos JP, Chaddad-Neto F, Lopes A, Oliveira E. Bone flap management in neurosurgery. Rev Neurocienc, in press.

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Recebido em: 17/10/07  
Revisado em: 18/10/07 a 12/03/08  
Aceito em: 13/03/08  
Conflito de interesses: não

## INTRODUCTION

Bone flap removal procedure is growing in frequency in neurosurgical practice. Decompressive craniectomy has gained more scientific evidences of its therapeutical value in post-traumatic brain swelling, in cerebrovascular diseases (occlusive and haemorrhagic) and in brain edema non-responding to clinical treatment after elective surgeries.

Different ways of preserving the bone flap for posterior cranioplasty at a delayed occasion and techniques of reconstructing the bone defect with synthetic materials are available. When a surgical site infection is present different considerations on keeping or dumping the bone flap and how to treat the infection can be made.

In this article, a literature review on how to manage the bone flap in different situations of the neurosurgical practice is presented.

## METHOD

A literature review on Medline database without publication date restrictions was made, selecting 18 articles among the 408 found, with the use of the words: "flap", "bone" and "neurosurgery". The selection resulted of their greater pertinence to present knowledge. All the studies that were found are based in series of cases, retrospective or prospective.

## DISCUSSION

### Bone flap destination after craniotomy

In the literature, four possible fates are possible for the bone flap after craniotomy: 1) placing of the bone under the subcutaneous abdominal tissue, 2) preservation of the bone in the subgaleal space on the edges of the craniotomy, 3) freezing of the bone flap and 4) dumping the flap for delayed cranioplasty with synthetic material or bone graft resulting from cranial vault split. These techniques are described below.

### Bone flap placing under subcutaneous abdominal tissue

Bone flap placing under subcutaneous abdominal tissue is a common practice in many Brazilian neurosurgical centers. A paramedian abdominal incision, commonly transversal, with dissection of a space under the subcutaneous tissue and placing of the bone flap is made. The abdomen must be prepared before the craniotomy is performed to avoid flap contamination.

Movassaghi et al. evaluated the efficacy of bone flap placement in the abdomen of 53 patients, being successful in 49 with one time reconstruction<sup>1</sup>. In eight cases the use of synthetic material was necessary to complement the cosmetic effect of the procedure. One patient needed a surgical revision for cosmetic purposes and three had flap infection, one of them with the flap still in the abdomen. They concluded that the abdominal bone flap preservation is effective and has a low complication rate.

Hauptli et al. related 43 cases of bone flap placement in the subcutaneous abdominal tissue, obtaining only three unfavorable outcomes: one patient presented bone infection and two had local absorption<sup>2</sup>. They emphasized that this technique was better than the freezing with less bone loss by absorption.

Tybor et al., after studying 36 cases of flap implants preserved in the abdominal wall (median 14 days between the surgeries), had one case of flap infection in 28 implants<sup>3</sup>. Two patients had the flap removed out of the abdomen for subcutaneous hematoma other by abdominal wall inflammation. They considered that bone flap preservation in the abdomen has cosmetic, financial, and technical advantages when compared to the use of synthetic prosthesis and has low inflammatory complication events.

Josan et al. evaluated a series of 24 children that underwent 28 cranioplasties, being 16 of them with patient's autologous bone flap, eight with cranial vault split, three with acrylic and one with titanium prosthesis<sup>4</sup>. Of the 14 patients submitted to cranioplasty with autologous craniotomy bone flap, three had flap infection, (after debridement and antimicrobial therapy successful implant was achieved in two cases). In one of the eight patients that underwent cranial vault split surgical debridement of the surgical wound without bone removal was necessary. They concluded that the low morbidity rate justifies the use of autologous material every time possible and its implant after debridement even if infected. Flannery and McConnel<sup>5</sup> also defended the bone flap placement in the subcutaneous abdominal tissue because it is a safe, efficient and low cost technique.

### Flap in the subgaleal space

The bone flap from the craniotomy is placed in the subgaleal space on the other side of the head, respecting the curvature of the cranial vault. The sharp bone edges are removed and the flap is anchored to the borders of the

craniotomy, leaving subgaleal drainage in place. When a bi-frontal craniotomy is performed, the flap is split in half and anchored bilaterally<sup>6</sup>. It's important to notice the cosmetic effect, even temporary, of the bone flap placement on the adjacent calvaria.

Krishnan et al. reported only two complications among 55 cases of bone flap placing in the subgaleal space: one case due to cutaneous perforation by a bone sharp edge and other by skin necrosis due to a small subgaleal space created by the dissection<sup>6</sup>. They alleged that this technique avoids the abdominal incision, shortens the duration of the surgery, being at the same time effective and having low morbidity rate.

Korfali et al. also defended the bone flap placement under the flap for delayed cranioplasty (performed between 12 to 48 days after the first surgery) after analyzing 37 cases without complications with this technique<sup>7</sup>.

Goel et al.<sup>8</sup> with eight cases and Pasaoglu et al.<sup>9</sup> with 27 cases implanted between 14 to 98 days, also had no complications.

#### Freezing of the flap on a bone-bank

The flap is cleaned and placed in a sterile plastic bag, being freezed in a special container for bone preservation after correct identification, as determined by the institution's protocols.

Iwama et al. reported two complications among 49 patients with flaps conserved by this technique with a median time of 50.6 days: one case of absorption and other of flap infection<sup>10</sup>. In some cases, there was "shrinking" of the bone without cosmetic or clinical compromise. The authors defended this method for bone preservation.

On the other side Hauptli et al. alleged significant bone loss in 60% of the cranioplasties performed after freezing of the flap, defending the placement of the flap in the subcutaneous abdominal tissue<sup>2</sup>.

#### Dumping the flap

Dumping the flap is a common practice with many neurosurgeons in emergency surgeries. We found no reports in the literature of the percentage of discarded bone flaps. We believe it is an acceptable practice when an infection of the surgical site is apparent. Greater evidence is needed to evaluate this opinion.

#### Cranioplasty

Cranioplasty's goals are the cosmetic restoration and brain protection, along with eventual benefit on cerebral blood flow auto-regulation that might explain the neurological improvement observed in some patients after the surgery<sup>11</sup>.

There are different materials that can be used, like autologous bone graft and materials like methylmetacrilate, titanium, mamone's polymer, among others. Many authors prefer autologous graft when available, due to its lower cost, good cosmetic result and acceptance by the patient.

The only study comparing infection rates with the use of different materials was performed by Matsuno et al., which analyzed possible factors implicated in the infection rate of grafts in 206 cranioplasties<sup>12</sup>. They observed 54 cases of autologous freezed bone after sterilization by heat; polymethylmetacrilate (PMMA) was used in 55 patients. Pre-made molds with PMMA were used on three patients, titanium in 77 and ceramic in 17. The authors obtained a greater infection rate with autologous grafts and PPMA when compared to those in which titanium was used.

The reconstruction with synthetic materials of body parts through computer programs has been used in neurosurgery to the production of cranial prosthesis with success<sup>13</sup>. Chiarini et al. reported 15 cases of pre-made acrylic prosthesis using CT reconstruction, without complications, with good cosmetic results<sup>14</sup>. The use of pre-made prosthesis shortens the duration of surgery (from 16 to 41%), has better cosmetic result, but is more expensive than the prosthesis made during the surgical procedure. Another advantage of the use of pre-made prosthesis with PPMA is the avoidance of in loco polymerization of the material and the problems that it can generate (exothermical reaction with damage to dural and sub-dural structures, entering of the product in the blood stream, causing systemic arterial hypotension)<sup>13</sup>. There are no comparative data of infection rate between pre-made prosthesis and those made in loco. The pre-made prosthesis is gaining greater importance when the patient flap cannot be used.

#### Flap infection after craniotomy

Infection rate after craniotomy is different from department to department. In a great multicentric French study of 2,944 patients that underwent a craniotomy, 117 (4%) presented surgical site infection<sup>15</sup>. Of those, 30 presented cutaneous infec-

tion and 14-bone infection, with flap compromise. Facing this results one may question if the patients with bone infection should have their flap removed.

Bruce et al. stated the following risk factors for bone infection after craniotomy: previous craniotomies, radiotherapy and skull base surgery (involving the paranasal sinuses)<sup>16</sup>. In 13 cases, obtained the following results after debridement, washing, anti-microbial therapy, and flap implant: five patients without risk factors resolved the infection; of the eight patients with risk factors, six had resolution of the infectious process, being that two were submitted to re-opening of the wounds without flap removal. Only two patients had no infection control, possibly for being flaps of craniofacial surgery, involving the facial sinuses. They concluded that the patients without risk factors for infection must be submitted to debridement and local washing without bone flap removal at least once.

Auguste et al. performed debridement plus continuous washing with anti-microbial drugs for five days in 12 patients that presented with bone flap infection<sup>17</sup>. In 11 they obtained complete resolution of the infection. On the other case, previous radiotherapy and surgery involving the facial sinuses were the assumed causes for the loss of the flap.

About bone flap contamination, Jankowitz et al. retrospectively analyzed 14 cases of accidental intra-operative fall of the flap to the floor<sup>18</sup>. Eight flaps were washed with iodine solution or antibiotics, two sterilized by heat, three replaced by synthetic implant, being one case destination unreported. They had no infections. An additional questionnaire was sent to 50 neurosurgeons. 83% of them wouldn't discard the flap and 66% of them had experienced a similar experience. In this way, the authors suggest that the intra-operative contamination of the flap is not uncommon and does not necessarily mean discarding the flap being its disinfection a viable option.

## CONCLUSION

Even after the review that was made, it's not possible to state with statistically significant certain if a conduct is, in fact, superior to the other. To make such a statement, a meta-analysis or prospective, randomized, multicentric studies must be performed. Meanwhile, some factors make us chose a particular conduct, always reminding that it must be adapted to the existent reality in the place we work, like the resources available, special materials, surgical equipments, surgeons experience and local infection rates.

About bone flap preservation, it can be made in bone-bank when available or in the subcutaneous abdominal or subgaleal spaces, with low complication rates and good cosmetic results. Discarding the flap and delayed cranial vault reconstruction with synthetic materials can be performed in those cases where bone flap preservation is not possible.

When an infection of the surgical site occurs and a surgical debridement is necessary, several articles defend the maintenance in place of the bone flap, after careful debridement and washing, as long as there are not present signs of bone destruction and the risk factors previously mentioned for the persistence of infection are absent, like in skull base surgeries involving facial sinuses or previous radiotherapy. In cases of intra-operative contamination, a strain of not discarding the bone flaps exists, recommending their maintenance after washing with low infection rates.

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