Journal of Cranio-Maxillo-Facial Surgery 45 (2017) 312–318

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Analysis of the factors affecting outcome after combat-related cranial defect reconstruction

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ARTICLE INFO

Article history:
Paper received 22 March 2016
Accepted 24 November 2016
Available online 1 December 2016

Keywords:
Firearm injury
Head trauma
War surgery
Cranioplasty
Outcome

ABSTRACT

Introduction: Reports on the outcomes of cranioplasty after combat-related injuries are relatively rare in the current literature. We present our results on the reconstruction of cranial defects resulting from injuries sustained in combat, comparing outcomes using autologous (iliac bone) grafts or (acrylate) allografts, and analysis of other factors that may influence the final outcome.

Material and methods: The study comprised 207 patients with cranial defects resulting from combat-related injuries, repaired with autografts or allografts. The final outcome was defined at least 5 years postoperatively on the basis of cosmetic restoration and the existence of complications as successful (acceptable cosmetic restoration + absence of complications) or unsuccessful (poor cosmetic restoration or acceptable cosmetic restoration + complications).

Results: Successful outcomes were achieved in 83.6% of patients; there was no operative mortality. There were 25 instances of complications: postoperative infection (n = 15, allograft (7/53), autograft (8/154)), autograft resorption (n = 8), and in two cases, graft luxation. Poor cosmetic restoration was noted in 9 (4.3%) patients who had received an autograft.

Conclusions: Thin and poorly vascularized skin, a surface area of the defect larger than 88 cm^2, previous local infection and communication with paranasal cavities significantly influenced outcomes after combat-related cranioplasty, the final three being independent predictors of an unsuccessful outcome.

1. Introduction

Traumatic brain injury may account for up to one third of combat-related injuries on today's battlefield (Meyer et al., 2008). Thorough debridement of devitalized bone or decompressive craniectomy results in cranial defects which require later cranial reconstruction (Tantawi et al., 2012). Cranioplasty of combat-related cranial defects has several specific characteristics: primary bacterial wound contamination, large epidural dead spaces as a result of severe brain injury, often thin and poorly vascularized soft tissue above the cranial defect, large dimensions of the cranial defect or complex craniofacial bone defects (Carey et al., 1971; Kumar et al., 2012; Tantawi et al., 2012). Reports on outcome after cranioplasty are relatively rare in the current literature (Rish et al., 1979; Khil'ko et al., 1994; Stephens et al., 2010; Kumar et al., 2011; Tantawi et al., 2012). Traditional management of compound depressed skull fractures entails elevation and removal of all bone fragments with delayed cranioplasty, in order to reduce postoperative infection. Because of the bacterial contamination of the wound, cranioplasty is contraindicated during the primary management of combat-related craniocerebral injury (Delashaw and Persing, 1990; Wylen et al., 1999), but the ideal time to cranioplasty is not precisely defined.

Cranial defects can be reconstructed with autologous bone grafts or allografts. Dilemmas about what graft material should be used for cranioplasty still exist in the modern literature, although the advantages and disadvantages of both methods are well recognized (Linder and Romanus, 1976; Kawakami et al., 1989; Delashaw and Persing, 1990; Pochon and Kloti, 1991; Inoue et al.,

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http://dx.doi.org/10.1016/j.jcms.2016.11.019
1010-5182/

1995; Lee et al., 1995; Durand et al., 1997; Gautschi et al., 2010). The advantages of acrylate are: better cosmetic restoration (easier moulding), shorter operative time, and the possibility of covering large defects; the advantages of an autograft are availability, biocompatibility, provision of bone cells, stimulation of osteoprogenitor cells and fast incorporation (Pochon and Kloti, 1991; Inoue et al., 1995; Lee et al., 1995; Stevenson et al., 1996; Blum et al., 1997; Azmi et al., 2004; Aydin et al., 2011; Gosain et al., 2011; Gilardino et al., 2015).

Complications are possible in both surgical techniques. Harvesting an autograft can cause complications at the donor site (haematoma, fracture, pelvis instability, infection, iliac hernia, chronic pain) or on the graft itself (infection and resorption) (Chan et al., 2001; Yamamoto et al., 2001; Howard et al., 2011; Ovalioglu et al., 2011; Kim et al., 2013; Brommeland et al., 2015). Obtaining a large enough bone graft to cover the cranial defect sometimes requires bilateral iliac bone harvesting. The shaping of the bone is more difficult than acrylate, and can result in poor cosmetic restoration, especially in frontoorbital cranial defect localization (Stula, 1984; Delashaw and Persing, 1990). Also, with older patients, bone resorption is dominant with regard to bone formation in the bone remodelling process.

After application of an allograft, luxation, rejection, infection and skin ulceration are possible, especially in thin and poorly vascularized soft tissue above the cranial defect (Linder and Romanus, 1976; Alesch and Bauer, 1985; Delashaw and Persing, 1990; Gladstone et al., 1995; Gautschi et al., 2010).

The risk for infection is increased because of allograft encapsulation with fibrous tissue (Gladstone et al., 1995). Some authors use only autografts in patients with previous infection, poor vascularization or communication with frontal sinus in the cranial defect region, such as patients with cranial defects resulting from combat-related injuries, where infection can be assumed (Kawakami et al., 1989; Inoue et al., 1995), while some suggest that autografts can safely be used, even if the wound is contaminated, with slightly increased risk of infection (Wylen et al., 1999; Bruce and Bruce, 2003; Akram et al., 2007).

Reports on outcome after cranioplasty are relatively rare in the current literature; moreover, the risk factors for a successful cranioplasty are not precisely defined (Rish et al., 1979; Khil'ko et al., 1994; Stephens et al., 2010; Kumar et al., 2011; Tantawi et al., 2012).

The war in our region resulted in a large number of craniocerebral injuries, which required later cranioplasty. As graft material we used monocortical autologous iliac bone grafts or acrylate in accordance with the opportunities.

We present our results of cranial defect reconstruction after combat injuries comparing outcomes using autologous (iliac bone) grafts or allograft (methylmethacrylate) flaps, analysing other factors that may potentially influence the final outcome.

2. Materials and methods

2.1. Patient selection

250 patients underwent cranioplasty with auto or allograft in our institution between 1991 and 2003. In certain periods all cranioplasties were performed with autografts because of the lack of allograft materials. In periods when allografts were available, the use of material depended on the surgeon's preference. Forty-three patients were excluded from the study (address change, death or failure to appear at follow-up examinations). Data on 180 patients stored in the medical database were analysed retrospectively, and prospective study of these individuals was initiated after follow-up examination. A prospective study was undertaken for 27 patients from the date of admission to our hospital. The inclusion criteria were as follows: combat-related cranial defect, absence of local infection (proven by clinical examination, CT scan and blood tests), absence of liquorrhea in the defect region, absence of malnutrition or serious organ system failure.

2.2. Initial surgical treatment

Initial surgical treatment after craniocerebral injury included removal of devitalized soft tissue and bone fragments with craniectomy, removal of devitalized brain tissue, easily accessible intracerebral bone and metal fragments and intracranial haematoma. The dura was closed and rendered watertight, which in almost all cases required a dural autograft (periosteum, temporal muscle fascia, fascia lata) or allograft. Soft tissues were closed without suture tension.

2.3. Cranioplasty

Operations were performed under general anaesthesia. The patient was positioned so as to place the cranial defect in a horizontal position and render all parts of the defect easily accessible. The incision followed that of the initial operation. The skin flap was separated from the dura as thickly as possible. The edges of the cranial bone defect were clearly displayed and in some cases a thin layer of bone at the edge of defect was removed (usually on two sides) in order to open the diploic blood vessels in the recipient region and achieve better autograft vascularization. If communication with paranasal cavities was noted, it was closed with abdominal fat, followed by reconstruction of the sinus wall with periost, temporal fascia or fascia lata. In some cases, we used a rotational temporal muscle flap for sinus reconstruction. In nine patients the skin could not be closed without tension after graft implantation, so relaxing incisions were made.

2.3.1. Cranial defect reconstruction with autograft

Monocortical bone grafts were harvested from the iliac crest in the typical manner. The graft was shaped with an osteotome according to the configuration and rigidly of the cranial defect then was fixed with at least three non-resorbable sutures. If the graft did not cover the entire surface of the cranial defect, another iliac graft was harvested from the other iliac crest. In these cases the grafts were connected to each other after shaping, and then set into the cranial defect.

2.3.2. Cranial defect reconstruction with allograft

Polymethylmethacrylate was used for allografts. After mixing the two acrylic components and achieving a pasty consistency, the acrylate was shaped by hand. In patients with a sinking skin flap, the epidural space was filled with wet gauze to achieve an approximate skull contour. After shaping, the flap was removed from the cranial defect until the exothermic reaction had completed, to prevent thermal tissue damage. In some cases perforations were made in the allograft, in order to achieve better drainage and graft fixation. The graft was fixed with at least three non-resorbable sutures.

2.4. Postoperative care

Drains were removed 24–48 h after the operation, when drainage was less than 50 cc. Subsequent epicranial collections were removed by puncture under sterile conditions, and treated with compressive dressings until coalescence between the skin flap and the graft occurred. Cephalosporines or aminoglycosides (for those allergic to cephalosporines) were used for antibiotic prophylaxis over a one-to ten-day period.