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Subcranial craniotomy approach for frontobasal fracture correction

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ABSTRACT

Objective: Frontobasilar fracture types and the outcome of patients after management with the subcranial approach technique were evaluated.
Material and methods: A retrospective analysis of 48 patients (45 males, mean age 38,5 years; range 16–82 years) who had a subcranial approach for frontal base fracture correction between April 1996 and April 2011 at a tertiary care academic hospital in Turku, Finland.
Results: Sixteen (33%) patients had fractures including all frontobasilar fracture types (Type I-IV) i.e. fractures that involved frontal sinuses, orbital roofs, ethmoidal region, cribriform plate and sphenoidal region. Twenty-seven (56%) patients were considered to have had brain damage at presentation. Forty percent of patients were suffering from synchronous trauma. Peroperatively, 31 (65%) patients had exposure or defect of the dura due to bone dehiscence but only two patients suffered from cerebrospinal fluid (CSF) fistula following surgery. CSF fistulae were covered by pericranium in most of the cases (68%). There was no postoperative meningitis. Thirty-eight percent of the patients needed further operation with a subcranial craniotomy following primary reconstruction. At the last follow-up visit 35% were suffering from permanent neurological problems following brain injury.
Conclusions: Subcranial approach seemed successful in the management of all frontobasilar fractures in this series with reasonably low complication rate. Therefore, we would recommend it as the technique of choice in multiple and even in the most complicated frontal base fractures.

1. Introduction

The anterior cranial base consists of the upper midface and the anterior skull base i.e. roofs of orbita, posterior wall of frontal sinus, ethmoidal complex and walls of sphenoid sinus. Injuries of anterior cranial base are mainly caused by high-energy trauma (Burstein et al., 1997; Perheentupa et al., 2010; Thoren et al., 2010; Calderoni et al., 2011; Naveen Shankar et al., 2012). One quarter of all patients with head injuries suffer from a fracture of anterior skull base (Rocchi et al., 2005).

Traditionally the fractures of the anterior cranial base are operated on by combined coronal approach and transfacial technique or by the frontal craniotomy (Schaller, 2005). The subcranial approach was initially introduced by Raveh in 1978 for the reconstruction of anterior cranial base fractures (Raveh and Vuillemin 1988a; Raveh et al., 1988). The same approach was used for the removal of anterior skull base tumours and reconstruction of craniofacial anomalies (Raveh and Vuillem, 1988, Raveh et al., 1995, 1998; Fliss et al., 2007). With this technique it is possible to operate on lesions in the nasal, orbital, spheno-ethmoidal and clival regions and to repair fractures involving dural defects and CSF fistulas and to decompress the optic nerve without extensive manipulation of the frontal lobe. Furthermore, the facial incisions are avoided by the coronal incision and in general the overall morbidity is low (Raveh et al., 1995; Fliss et al., 1999, Kellman and Marentette, 2001; Hendryk et al., 2004). The subcranial approach offers wide exposure to anterior skull base below the traditional transfrontal approach allowing easy access to simultaneous repair of dural defects (Fliss et al., 2007). Recently, transnasal endoscopic techniques have gained success, but in multiple fractures, or in fractures involving nerve injuries, an open approach still is a reasonable treatment option (Kirtane et al., 2005; Scholsem et al., 2008; Liu et al., 2010).

The purpose of the present study was to review the types of frontobasilar fractures and in addition the management and

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outcome of all frontobasal fracture patients treated by the subcranial approach at our institution during a 15-year period. Detailed information of the current indications and patient selection for subcranial craniotomy and its outcome and complications was needed to improve management decision making for this patient population.

2. Material and methods

Clinical data of all patients diagnosed with frontobasilar fractures during the period from April 1996 to April 2011 at the Turku University Hospital (TUH), Turku, Finland were reviewed retrospectively. The health care district included in this study covers an area of approximately 7,50,000 inhabitants with TUH as the only centre treating severe trauma patients. Hospital surgical and discharge registries were used to identify the patients according to International Classification of Diseases, 10th edition (ICD-10) codes for skull base fractures (S02.10-S02.11) and the surgical procedure codes according to Nordic Classification of Surgical Procedures for closure of cerebrospinal fistula (AAK40) and for other operations by a cranial base approach (AAE99). The present study population was identified from this larger cohort of 475 patients using the criterion of subcranial craniotomy as the main surgical procedure. A total of 48 consecutive patients (45 male, 3 female, mean age 385 years; range 16–82 years) were included. The hospital records were reviewed and details were collected on the patients' age, sex, socioeconomic status, type of fracture, trauma mechanism, physical findings at presentation, Glasgow Coma Scale (GCS) score, CT imaging, intracranial involvement, treatment and length of stay at the intensive care unit (ICU), synchronous trauma, details of operative management of the trauma, length of hospital stay and outcome (Glasgow Outcome Scale, GOS, Table 3). The traditional GOS divides outcome at 6 months after injury into five categories; good recovery, moderate disability, severe disability, vegetative state and death (Jennett et al., 1981). Frontobasilar fractures were classified into four categories i.e. into Types I to IV according to the anatomy and pathological intraoperative findings of the trauma (Escher, 1969a, Stoll, 1993, 1999). Type I fracture included frontal sinus fractures including either anterior or posterior or both tables, with or without CSF leakage. Type II fracture included fracture of anterior and/or posterior ethmoid sinus and cribriform plate with or without CSF leakage. Type III fractures included sphenoid sinus injuries with or without CSF leakage and type IV included fractures of orbital roof with or without CSF leakage.

The surgical technique is described in detail elsewhere (Raveh and Vuillemin, 1988a, 1988b; Raveh et al., 1995, 1998; Fliss et al., 1999; Kinnunen and Aitasalo, 2006). Preoperatively, the general condition of the patient and operative indications were evaluated by a multidisciplinary team including an anesthesthetist, a neurosurgeon and a neurologist when needed. Briefly, under general endotracheal anaesthesia the coronal incision was used and skin flaps were raised in supraperiosteal plane. Any skin lacerations caused by the trauma could be used to expose the surgical area. The flap was elevated anteriorly over the supraorbital ridges and laterally superficial to the temporal muscle fascia. The supraorbital nerves and vessels were separated from the supraorbital notch. After entering the orbits the anterior ethmoidal arteries were coagulated. The osteotomy to obtain an en-bloc fronto-naso-orbital part was performed and the osteotomized complex was then removed and stored in a saline solution. Also the existing traumatic fracture lines could be used in certain cases. Bilateral ethmoidectomy to the extent needed or spheno-ethmoidectomy were performed to achieve broad exposure of anterior cranial base. Dural lacerations were sutured and covered by fascia-lata, pericranium or temporal fascia and fixed with fibrin glue. Polyethylene tubes (Portex®, Sims Portex Ltd., Kent, UK) were placed from frontal sinus to nasal cavity to provide aeration and re-growth of sinus cavity mucosa. The bony complex was then repositioned and fixed with either titanium or biosorbable miniplates and screws. Patients were followed after the injury for approximately 19 months (from 0 to 110 months). Those who were not followed at our institution were transferred to another hospital.

An institutional research approval was granted for the study.

Table 1
Complications following frontobasilar fracture correction by subcranial craniotomy.

Post operative diplopia	19/48	40%
Ptosis	8/48	17%
Enopthalmus	13/48	27%
Telecanthus	3/48	6%
CSF leakage	2/48	4%
Meningitis	0/48	0%
Frontal sinus mucocele	2/48	4%
Olfactory dysfunction	15	31%
Nasal congestion	5/48	10%
Palpable bony defect	12/48	25%
Lacrimal duct dysfunction	4/48	8%
Soft tissue scar	7/48	15%
Soft tissue fistula	3/48	6%
Neuralgic pain	4/48	8%
Pseudoaneurysm	1/48	2%

Table 2
Further operations after subcranial craniotomy approach (total number of patients who needed further operations was 18, total number of procedures was 25).

Procedure	Number of patients
Closure of tracheostoma	5
Dacryocystoscopy (+-stent)	3
Removal of fixation material	5
Correction osteotomy	2
Revision (wound + -re-attachment of Portex)	2
Strabismus operation	2
Rinoplasty	1
Coil, ligation and obliteration of pseudoaneurysm	1
Condylectomy	1
Tarsoraphy	1
Closure of CSF fistula by re-operation	1
Vitrectomy and lensectomy	1

3. Results

3.1. Socio-economical status

Twenty-six (54%) patients were labourers, five (10%) were unemployed or their sosio-economic status was not available, three (6%) were lower-level employees with administrative or clerical occupations, three were students and two (4%) were upper-level employees with administrative, managerial, professional or related occupations and retired persons (aged 65 and 82 years), respectively.

3.2. Occupational injuries

Seven out of 48 (15%) cases were occupational injuries. All patients with occupational injuries were labourers. Four of them

Table 3
Glasgow Outcome Scale (5 = good recovery, 4 = moderate disability, 3 = severe disability, 2 = vegetative state, 1 = death).

Good recovery	25/34	(74%)
Moderate disability	7/34	(21%)
Severe disability	0	(0%)
Vegetative state	0	(0%)
Death	2/34	(6%)