**Title Page**

**Full Length Article:**

**Review of Frontal Sinus Fracture Outcomes from a Tertiary Multispecialty Craniofacial Trauma Service**

**Abstract**

**Introduction:** There are no agreed national guidelines for the treatment of FS/NOE. The Oxford University Hospitals Craniofacial Trauma unit was set up 5 years ago as a joint Oral & Maxillo-facial and Neurosurgical service. We present our experience to date in the treatment of patients with Frontal Sinus (FS) and Naso-orbito-ethmoid fractures (NOE).

**Method**: The study included 91 patients with data collected from a prospective database and retrospectively from medical records using a pre-designed proforma. Patients underwent cranialisation if they met the criteria of persistent CSF leak, displaced posterior wall fracture or Naso-Frontal Outflow Tract (NFOT) obstruction. The average follow-up time was 3 years and 6 months (range 1-10 year).

**Results**: Data showed male:female ratio 6:1 with mean age of 34 (range 9-76). Data included mechanisms of injury (35% RTA, 23% fall from a height, 10% assault, 2% gunshot, 30% other). Three patient groups were analysed. Group 1 underwent cranialisation (n=50). Group 2 met the criteria for cranialisation but were treated conservatively due to comorbidities (n=8). Group 3 were treated conservatively (n=33).

Combined percentage outcomes for infection, mucoceole and need for further surgery where 8% for Group 1, 38% for Group 2 and 9% for Group 3. There was a statistically significant reduction in complications for patients who met the operative criteria and underwent cranialisation compared with conservative treatment(p=0.04).

**Conclusion**: We present outcomes from one dedicated multi-specialist Craniofacial Trauma Unit in the UK, which may inform benchmarking for care of patients with this specific group of injuries.

**Keywords**: Frontal Sinus, Craniofacial, Trauma, Maxillo-facial, Cranialisation, Naso-Orbito-Ethmoid

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**Introduction**

Frontal sinus fractures make up 5% of facial trauma (1). The injuries are associated with a significant risk of morbidity and mortality. The frontal sinus is a mucous membrane lined chamber, which varies in size amongst individuals. The posterior wall of the sinus forms part of the anterior cranial wall and is lined with dura. The anterior wall contributes to the contour of the forehead. The floor of the sinus contains the nasofrontal outflow tract (NFOT), which allows drainage of the sinus content into the nasal cavity.

Fractures of the posterior wall of the sinus may be associated with dural tear and communication of the sinus with the sterile cranial chamber increasing the risk of meningitis (2). Obstruction of the NFOT can cause stasis within the sinus leading to sinusitis and mucocele (3). Repair of the frontal sinus also carries its own operative risks including infection, intracranial heamorrhage and parenchymal trauma.

At the Oxford University Hospitals NHS Trust, a craniofacial trauma service has been established which is jointly run by the oral and maxillofacial, neurosurgical and ear nose and throat surgical teams. All patients who present with frontal sinus or naso-orbito-ethmoidal fractures are managed in the acute phase by the craniofacial trauma team and managed in accordance with an agreed protocol (chart 1). Management is determined by the fracture pattern. The majority of patients present acutely following injury. However, a small number of patients have presented with late complications of frontal sinus fractures treated before the advent of the craniofacial trauma service or who were acutely managed at another hospital.

The purpose of this paper is to describe the management protocol at the Oxford University Hospitals NHS Trust and use follow-up data to date to validate the safety of this protocol.

*Treatment: Transcranial Cranialisation*

Cranialisation was first described by Donald and Bernstein in 1978 (4). This is based on previous studies associating an increased lifetime risk of infection with displaced posterior wall fracture. Displaced posterior table is defined by a displacement greater than the width of the bone(5). Nasofrontal outflow tract is diagnosed from review of CT scan of less than 2mm thickness in sagittal, coronal and axial slices.

Cranialisation is performed as a joint procedure with neurosurgeons and oral and maxillo-facial surgeons. It is performed via a coronal flap, with frontal craniotomy for access. The posterior table of the sinus is removed and any dural tears are repaired. The walls of the sinus are drilled to remove any remnants of sinus mucosa. The outflow tract is obliterated with bone fragments. A vascularized pericranial flap is inserted over the cranialised sinus, underneath the frontal lobe. The frontal lobe is allowed to expand into the frontal sinus space and the craniotomy bone flap is replaced with miniplates. Patients are not routinely given antibiotics pre-operatively. All patients receive a dose of antibiotics and dexamethasone at the start of the operation and the subsequent 24 hours.

All patients are managed in the acute phase by the craniofacial trauma team. Following discharge, patients are reviewed at 6 months and subsequently annually for 10 years. During this time patients undergo a routine surveillance CT at 1, 5 and 10 years post-surgery. Additional scans may be indicated based on clinical review.

*Conservative treatment*

These patients do not receive surgical or medical intervention. They are followed up routinely by the craniofacial trauma service. This involves a review at 6 months and subsequently annually for 10 years. During this time patients undergo a routine surveillance CT at 1, 5 and 10 years post-surgery. Additional scans may be indicated based on clinical review.

**Materials and Method**

Oxford University Hospitals NHS Trust is a regional level 1 trauma unit covering a population of 2.5 million from Oxfordshire, West Berkshire, Buckinghamshire and Swindon.

*Patient selection*

All patients who sustained a frontal sinus or NOE fracture, during the years 2006-2014 in the catchment area of the Oxford OMFS department were followed up in the craniofacial trauma clinic and included in this study. These Patients were identified for inclusion in this study using the hospital outpatient clinic database.

The exclusion criteria included isolated anterior sinus wall fracture, death before discharge from hospital, late presentation with complications not initially treated by the craniofacial trauma team, follow-up period of less than 1 year and repeat craniofacial injury. This excluded 28 patients and left a remaining 91 for analysis.

*Data collection*

Data was collected prospectively using a pre-designed database. This included patient age, gender, mechanism of injury, other injuries sustained, GCS on admission, the primary definitive surgical procedure undertaken and the latest time of follow-up. A further retrospective review of medical records allowed completion of data gaps.

The type of fracture was classified into: undisplaced posterior table, displaced posterior table, nasofrontal outflow tract obstruction, NOE or combination. Displaced posterior table fracture was defined as fracture displacement greater than the width of the displaced bone fragment. All patients underwent pre-operative multi-axial (sagittal, transverse and coronal) fine cut (<2mm slice thickness) CT scan. The CT scans of each patient were retrospectively reviewed and reported for this study by a Consultant Neuroradiologist. This was used to confirm the fracture type and presence of NFOT obstruction. Nasofrontal outflow tract injury was defined by one or more of the following: outflow tract/ductal “obstruction,” frontal sinus floor fracture, or fracture of the medial aspect of the anterior table.

Patients were placed into 3 groups for data analysis.

Group 1 (n= 50)

Patients with displaced posterior wall fracture and/or NFOT obstruction who underwent cranialisation.

Group 2 (n= 8)

Patients with displaced posterior wall fracture and/or NFOT obstructions that were treated conservatively with observation. These patients were treated conservatively due to comorbidities.

Group 3 (n=33)

Patient with undisplaced posterior wall fracture without NFOT obstruction. All patients in this group were treated conservatively with observation.

*Outcomes*

The primary outcome was need for further surgery to treat mucoceole, local bone or prosthesis infection, abscess and sinusitis and admissions to treat sinusitis or meningitis.

All calculated statistics was carried out using PASW Statistics 18. All calculations were completed assuming a 365 day year and 30 day month.

**Results**

A total of 119 patients with frontal sinus and/or NOE fracture were followed up in the craniofacial trauma service clinic between 2008-2014. Twenty eight patients were excluded from the analysis due to inadequate follow-up (20), insufficient data (6) and late presentation to the service (2). This presents data from 91 patients, which are included below.

There was a 6:1 male to female ratio with an age average age of 34 (range 9-76) at time of injury. The most common mechanism of injury was road traffic accident (35%) followed by fall from height (23%), assault (10%), gunshot (2%) and other (30%). The most common associated injuries where limb injuries followed by intra-cranial heamorrhage (table 1).

The overall mean follow-up was 3 years and 6 months with a range of 1 year to 10 years. Group data is summarised in table 2.

Group 1: Patients with displaced posterior wall fracture and/or NFOT obstruction who underwent cranialisation

Within this group 4 patients developed a complication. This gives an overall complication rate of 8%. Two patients developed infection and osteomyelitis of the craniotomy (post-operative day 44 and 43) requiring repeat procedures for washout followed by removal of fixation plates and cranioplasty. One patient developed a mucoele 3 years and 7 months after surgery, which was drained by endoscopy with good result and no recurrence. One patient developed a frontal lobe abscess (post operative day 26), which required stereotactic drainage with good result and no recurrence.

Group 2: Patients with NFOT obstruction or displaced posterior wall fracture treated without cranialisation

These patients did not undergo cranialisation due to their comorbidities, associated injuries, unstable ICP or cerebral and systemic infection. Within this group 3 patients developed a complication. This gives an overall complication rate of 38%. Two patients required late cranialisation due to frontal sinus infection. One patient had a persistent CSF leak and required endoscopic fat graft to seal the defect.

Group 3: Patients without NFOT obstruction or displaced posterior wall fracture treated without cranialisation

Within this group 3 patients developed pansinusitis, which was treated successfully with FESS procedure. This gives an overall complication rate of 9%.

*Statistical Analysis*

Complications rates between each group were compared using a Fisher Exact Test (table 3).

**Discussion**

Frontal sinus fractures form a minority (5%) of OMFS trauma cases however they are associated with a risk of life threatening sequeala including intracranial infection and mucoceole. The surgical treatment is invasive and a subspecialist procedure, which is also associated with significant complications including infection, seizures, heamorrhage and death. Weighing up these risks and deciding when to operate can be a difficult decision to make.

Many procedures have been described for the treatment of the frontal sinus with the aim to create a ‘safe sinus’. This can be achieved by maintaining sinus drainage via the NFOT, blocking the NFOT with obliteration of the sinus or cranialisation of the sinus space.

A posterior frontal sinus wall fracture may create a communication between the sterile intracranial space and the sinus with the risk of microorganism transfer. This risk is greater with displaced fractures due to the higher risk of dural tear(5). The complications related to CSF fistulae was highlighted in the work of El Jamel 1990 who quoted a 30.6% risk of meningitis which was reduced to 4% following dural repair. The mortality of meningitis can vary from 20-70%. Meningitis has been quoted to occur up to 34 years after traumatic CSF fistula formation (2).

Rodriguez et al showed a statistically significant higher complication rate amongst conservatively treated patients with NFOT obstruction irrespective of the frontal sinus fracture pattern. In this study one patient treated by cranialisation developed a mucoceole at 3 years and 7 months post-operatively. Obstruction of the NFOT is quoted to have 100% risk of infective complications if left untreated (3). This is hypothesized to be due to retained secretions and poor drainage of the sinus.

Naso-orbito-ethmoidal fractures are also associated with NFOT obstruction. Gerbino et al identified a subgroup of their patients with NFOT obstruction but intact posterior wall. This was a small group of 4 patients, all treated with stenting of the NFOT and no complications were reported. They also reported no complications in patients with intact NFOT function, identified by endoscopy, and intact posterior sinus wall (6).

At the Oxford Universities Hospital NHS trust, a multispecialty craniofacial trauma service has been established to treat patients who present with traumatic frontal sinus and NOE fractures. The decision to operate is based on an agreed local protocol. This is based on the best available published data. The outcomes presented support the safety of the agreed surgical indications for cranialisation. Patients who met the operative criteria but did not undergo cranialisation due to compounding comorbidities had a significantly higher incidence of complication. All patients presenting to the craniofacial trauma service are followed up for 10 years. Whilst many patients have not reached the end of the 10 year active follow-up period, data collection is being continued. A larger cohort study with a complete 5-10 year follow-up period is to be published in the near future.

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**Conflict of interest**: none

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