

CLINICAL OUTCOMES OF SURGICAL APPROACHES IN THE FRACTURES OF THE FRONTAL SINUS

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Abstract:

Frontal sinus fractures occur from trauma to the part of the frontal bone that overlies the sinus, often from motor vehicle accidents and falls. The hallmarks of a frontal sinus fracture are a frontal depression in the anterior table of the bone. Additionally, clear fluid leaking from the nose may indicate that fractures to the posterior table have torn into the dura mater, creating a cerebrospinal fluid leak.

Total 20 cases of the patients undergoing the surgery for frontal sinus injuries were evaluated in the present study was planned in Department of Oral & Maxillofacial Surgery, Buddha Institute of Dental Sciences & Hospital. The patients were divided in two groups. Group A includes the 10 cases in which care was taken in first 10 days. Group B includes the 10 cases in which care was taken after 10 days.

The data generated from the present study concludes that fractures of the frontal sinuses are more and more frequent and serious. They involve the vital, functional and aesthetic prognosis of patients, and must therefore require a safe method of management with ways of starting allowing both good security and better exposure.

Keywords: Craniofacial Trauma, Frontal Sinus Surgery, Cranialization, Exclusion of Sinus, etc.

Introduction:

The frontal sinuses are one of the four pairs of paranasal sinuses that are situated behind the brow ridges. Sinuses are mucosa-lined airspaces within the bones of the face and skull. Each opens into the anterior part of the corresponding middle nasal meatus of the nose through the frontonasal duct which traverses the anterior part of the labyrinth of the ethmoid. These structures then open into the semilunar hiatus in the middle meatus. Frontal sinuses are rarely symmetrical and the septum between them frequently deviates to one or other side of the middle line. Their average measurements are as follows: height 28 mm, breadth 24 mm, depth 20 mm, creating a space of 6-7 ml. The mucous membrane in this sinus is innervated by the supraorbital nerve, which carries the postganglionic parasympathetic nerve fibers for mucous secretion from the ophthalmic nerve and supplied by the supraorbital artery and anterior ethmoidal artery.

The frontal sinuses are absent at birth, but are generally fairly well developed between the seventh and eighth years, only reaching their full size after puberty.[2] The frontal bone is membranous at birth and there is rarely more than a recess until the bone tissue starts to ossify about age two. Consequently, this structure does not show on radiographs before that time. Sinus development begins in the womb, the maxillary and ethmoid sinuses are present at birth. Sphenoidal sinuses are present at birth as well but are very small. Approximately 5% of people have absent frontal sinuses.[3]

Through its copious mucus production, the sinus is an essential part of the immune defense/air filtration carried out by the nose. Nasal and sinasal mucosae are ciliated and move mucus to the choanae and finally to the stomach. The thick upper layers of nasal mucus trap bacteria and small particles in tissue abundantly provided with immune cells, antibodies, and antibacterial proteins. The layers beneath are thinner and provide a substrate in which the cilia are able to

beat and move the upper layer with its debris through the ostia toward the choanae.

Infection of the frontal sinus causing sinusitis can give rise to serious complications, as it is in close proximity to the orbit and cranial cavity (orbital cellulitis, epidural and subdural abscess, meningitis).[2] Endonasal approach into the frontal sinus in children with acute and chronic frontal sinusitis without the usage of surgical optics is not successful, because in this case the operation is performed almost blindly and technically difficult even in adults.[4]

Frontal sinus fractures occur from trauma to the part of the frontal bone that overlies the sinus, often from motor vehicle accidents and falls. The hallmarks of a frontal sinus fracture is a frontal depression in the anterior table of the bone. Additionally, clear fluid leaking from the nose may indicate that fractures to the posterior table have torn into the dura mater, creating a cerebrospinal fluid leak.[5]

Goals in management are to protect the intracranial structure, control any existing CSF leakage, prevent late complications, and aesthetically correct the deformity caused, if any. In anterior table fractures, if the table is minimally displaced, there will be no treatment necessary, only observation. If largely displaced, the correction is open reduction and internal fixation. If inhibiting the nasofrontal outflow tract, procedure is to undergo open reduction and internal fixation of the anterior table and osteoplastic flap with obliteration.

In posterior table fractures, a nondisplaced fracture with no CSF leak will only be observed. Those with a CSF leak will undergo sinus exploration if the CSF leak is not internally resolved within 4 to 7 days. With more dramatic displacements, sinus exploration will be required to determine the required level of cranialization, obliteration, and reparation to the dura.

The most appropriate treatment of frontal sinus (FS) fractures can be complex and, at times, controversial. The treating physician should have a clear algorithm in mind for management of different fracture patterns. The author proposes a conservative algorithm for the treatment of most FS injuries. Treatment options include observation, open reduction and internal fixation (ORIF), sinus obliteration, sinus exenteration (ie, removal of anterior table, Reidel procedure), and sinus cranialization. The algorithm is based on 5 anatomic

parameters that need to be evaluated before deciding on the most appropriate treatment option. These parameters include NFR fractures, anterior table fractures, posterior table fractures, dural tears (CSF leak), and degree of fracture comminution. Nondisplaced or minimally displaced (< 1-2 mm) isolated anterior table fractures can be managed conservatively with local wound care and analgesics. Patients should be closely observed for signs of frontal sinusitis, which may indicate fracture involvement in the nasofrontal duct.

General goals of surgical therapy include protection of intracranial contents, prevention of early and late complications (eg, meningitis, mucocele), restoration of aesthetic forehead contour, and return of normal frontal sinus (FS) function. Although accomplishing all these goals may not be possible, the intracranial contents must be protected, and a "safe" sinus must be reconstructed. Repair of aesthetic and functional deformities can be addressed secondarily. [6]

A study by Choi *et al* in which the investigators surveyed facial plastic surgeons with otolaryngology training, general otolaryngologists, plastic surgeons, and oral and maxillofacial surgeons found that 61.7% of respondents believed that endoscopic sinus surgery had altered their way of managing frontal sinus fractures. The study also found that when it came to uncomplicated, nondisplaced frontal sinus outflow tract fractures, 91.8% of the physicians surveyed favored observation. In terms of uncomplicated, displaced frontal sinus outflow tract fractures, 36.4% of respondents favored observation and 35.9% favored endoscopic sinus surgery. Plastic surgeons and oral and maxillofacial surgeons had a greater tendency to favor obliteration in complicated, displaced frontal sinus outflow tract fractures than did the physicians with otolaryngology training. [7]

A review by Dedhia *et al* of current trends and literature in the management of frontal sinus fractures remarks on the evolving conservative management of select cases and the expansion of such treatment due to the role of minimally invasive endoscopic sinus surgery techniques. The authors outline a new algorithm for treatment decisions and emphasize the need for follow-up of at least a year to monitor for possible complications. [8]

Nondisplaced fractures involving the floor of the FS or anterior ethmoid region should raise suspicion for nasofrontal recess (NFR) injury. In the absence of associated FS injuries, close observation and repeat

CT at 4-6 weeks may reveal sinus opacification, indicating outflow obstruction. If NFR injury is highly suspected, but it cannot be confirmed on the CT scan, a frontal sinusotomy and endoscopic evaluation is indicated. Displaced fractures usually require FS obliteration. Some authors have advocated more conservative approaches, such as NFR reconstruction with mucoperiosteal flaps (eg, Sewell-Boyden flaps) or intersinusseptectomy, which theoretically allows the injured sinus cavity to drain into the uninjured NFR. These techniques have not gained significant popularity.

Nondisplaced fractures can generally be managed nonoperatively. Nondisplaced anterior table fractures rarely result in mucocele formation, functional deficit, or aesthetic deformity. Advise patients of a small risk of external deformity, which can often be repaired endoscopically. [9] A study by Spinelli et al indicated that percutaneous screw placement can effectively be used for closed reduction of isolated fractures of the anterior frontal sinus. In the report, 15 patients with such fractures were treated with this technique. [10]

Position patient 180° away from anesthesia. Explore all forehead lacerations. Although lacerations alone are usually inadequate for exposure, diagnosis, and repair of FS fractures, they should be used to assist with fracture repair. For coronal flap dissection, part the hair in a widow's peak pattern 4-6 cm behind the anterior hairline. A 1- to 2-cm strip of hair can be shaved along the incision line, but this is not necessary. The scalp is incised and elevated in a subgaleal plane. Avoid brow incisions to prevent prominent scars and forehead anesthesia. Lateral flap dissection is performed between the temporoparietal fascia (superficial temporal fascia) and the temporalis muscle fascia (deep temporal fascia). The temporoparietal fascia and frontal branch of the facial nerve are elevated with the flap. The temporalis muscle fascia can also be incised and elevated with the flap to provide an extra layer of protection for the facial nerve. Identify and protect the supraorbital and supratrochlear neurovascular pedicles. The pericranium is incised 1-2 cm above the sinus and elevated below the fracture. If any concern about a posterior table injury or dural tear exists, elevate the entire pericranial flap from the coronal incision line. The vascularized pericranial flap may then be used for a dural repair. Reduce the concave fracture segments. If the fracture segments overlap, a

bone hook can be insinuated between the fragments and pulled forward.

Patients with mildly displaced anterior table fractures do extremely well after surgical repair, and significant long-term sequelae are uncommon. Displaced FS fractures generally result from more extreme forces. Consequently, most patients who undergo surgical treatment of these injuries have some long-term sequelae. The most common sequelae are mild and include frontal headache (20%), sinus infections (12%), sinus fullness (11%), sinus drainage (10%), and forehead depression (10%). Less common but more severe long-term sequelae include diplopia (4%), seizures (4%), mucocele formation (exact incidence uncertain [0-10%]), and brain abscess (1%).

Methodology:

Total 20 cases of the patients undergoing the surgery for frontal sinus injury were evaluated in the present study. It was planned in Department of Oral & Maxillofacial Surgery, Buddha Institute of Dental Sciences & Hospital. The patients were divided in two groups. Group A includes the 10 cases in which care was taken in first 10 days. Group B includes the 10 cases in which care was taken after 10 days.

• **Type I fractures of the anterior Wall**

- ✓ IA Without dislocation, no damage of the nasofrontal duct
- ✓ IB High fracture of dislocation, not of the nasofrontal duct
- ✓ IC fracture with bone loss, not of the nasofrontal duct
- ✓ ID Low fracture with involvement of the nasofrontal duct
- ✓ IE fracture of all anterior wall with involvement of the nasofrontal duct

• **Type II Posterior Wall fractures**

- ✓ IIA No dislocation, no cerebrospinal fluid (CSF) leakage,
- ✓ IIB dislocation and/or bone loss, no CSF leak
- ✓ IIC dislocation and CSF leak
- ✓ IID extensive and comminuted for the posterior wall with the CSF leak

• **Type III Fractures of both the anterior and the posterior walls**

- ✓ IIIA Type I + IIA or IIB
- ✓ IIIB Type I + IIC or IID.

• **Type IV Comminuted fractures of all complex nasofronto-ethmoido-orbital**

All the patients were informed consents. The aim and the objective of the present study were conveyed to

them. Approval of the institutional ethical committee was taken prior to conduct of this study.

Following was the inclusion and exclusion criteria for the present study.

Inclusion Criteria: All patients hospitalized for frontal sinus fractures, isolated or not, were included.

Exclusion Criteria: Any fracture that does not require a surgical indication was excluded.

Results & Discussion:

Of maxillofacial fractures 2 - 15% is frontal sinus fractures, the majority caused by traffic accidents. Single outer table fractures include 18 - 43% of frontal sinus fractures. [11] Fractures involving the frontal sinus are sustained primarily from forces that are applied directly to the anterior aspect of the skull in the glabellar region. Most fractures are the result of blunt trauma directed to this region. [12] These are associated with high-velocity blunt trauma to the head resulting in various fracture Penetrating injuries from gunshot wounds and industrial accidents are associated with greater concentration of force to a smaller area. These injuries are therefore associated with a greater risk of damage to both tables of the frontal sinus, dural tears, cribriform plate and fovea ethmoidalis fractures, as well as frontal lobe injury. [13]

Table 1: Type of injury

Type	No. of Cases
Type I	5
Type II	1
Type III	3
Type IV	11
Total	20

Table 2: Distribution according to reconstruction techniques

Groups	Group A	Group B
Care Taken	Within 15 days	After 15 days
Reconstruction techniques		
Sinus exclusion without filling	4	5
Cranialization	3	1
Suture for Small meningeal lacerations	1	1
Pericranial flap (larger defects)	1	1
Titanium grid (If the bony defect of the anterior wall was big enough)	1	1
Total No. of Cases	10	10

Table 3: General characteristics of the operative process

Groups	Group A	Group B
Care Taken	Within 15 days	After 15 days
Inflammatory complications	0	1
Neurological worsening after surgery	0	
Improvement of ocular function after surgery	Yes	Yes
Aesthetic sequelae	0	1
Postoperative functional sequelae:	2	0
Hyposmia	0	1
Anosmia	1	1
Headaches		

Inter-individual and intra-individual variations in the size and shape of the frontal sinus have been reported. These can have many clinical implications. [14] The fact that there is a lot of variation in the pattern of sinuses in individuals and every individual has a unique pattern of sinuses is utilized in forensic sciences for identification of the diseases. Based on this fact the Anatomy of sinuses is of particular value just like the identification of individual by finger print or DNA fingerprinting technique. In case the frontal sinuses get infected and the resolution does not occur by antibiotic therapy especially in case of small sinuses with inadequate drainage and abnormal textures there is a greater chance of infection getting localized and transforming itself into pansinusitis. In 1903, Killian was the first to operate for an infection in the frontal sinus; in 1904, he refined the submucous resection of the nasal septum. Osteoplastic obliteration of the frontal sinus, popularized by Goodale and Montgomery, provided a definitive procedure for recalcitrant frontal sinusitis and mucocoeles. Lately the Open procedures for the paranasal sinuses have been partially replaced by functional endoscopic sinus surgery.

Kim and colleagues in 2007 evaluated the endoscopic repair of isolated anterior table frontal sinus fractures with a Medpor implant in 10 cadaveric heads. [15] Five cadavers received prefabricated implants generated from the post injury CT data. Five Cadavers received a standard Medpor implant (0.85 mm sheet) (Porex Surgical Inc, Newnan, GA, USA) contoured intraoperatively. Medpor sheeting fixated to stable bone with a 1.7 mm self-drilling bone screw. All 10

defects were successfully repaired within 1 to 2 mm. Steiger and colleagues 2006 in their series stated that after 2 years of follow-up, all patients clinically showed good cosmetic results and were free of sinus complaints and radiographically had patent sinuses and reduced fractures. Steiger performed a frontal sinusotomy to access the fractured anterior wall and attempted transnasal endoscopic reduction using a frontal sinus curette and a Foley catheter balloon. [16]

In case of trauma which result in the Fractures of the frontal sinus/ sinuses can lead to the development of mucocoeles. Mucocoeles also follow duplication of the mucous membrane. They can gradually enlarge and destroy the part or whole of floor of the frontal sinus; as they expand into the orbital cavity, they produce proptosis and inferior and lateral displacement of the eye. These Mucocoeles and other forms of chronic frontal sinusitis that do not respond to medical management or endoscopic sinus surgery can be managed surgically by an osteoplastic flap approach for obliteration of the frontal sinus. The incision in the bone is made at the periphery of the frontal sinus, and the anterior wall is rotated inferiorly on the hinge of periosteum at the floor of the sinus. Trauma resulting in Fractures of the upper third of the face may be accompanied either by ocular or central nervous system (CNS) complications or both and can result in facial deformity. The most important and Pertinent facial fractures in this region are those of the supraorbital ridge, orbital roof, frontal sinus, and nasoethmoid or orbital area. Fractures of the orbital roof are frequently associated with frontal sinus and nasoethmoid fractures but may occur as an isolated injury or as an extension of a low frontal skull fracture. The loss of upward gaze in association with this fracture indicates involvement of the superior rectus muscle and possibly superior oblique muscles. Occasionally, a fracture of the orbital roof may be so comminuted as to defy repair, and debridement with primary or delayed bone grafting may be necessary. Comminuted upper and midface fractures are best repaired primarily with immediate bone graft, as delayed grafting is more difficult and has a higher complication rate especially in case of small sinuses with inadequate drainage. A basilar skull fracture should also be suspected when an air-fluid level is seen on the lateral skull film in the frontal, sphenoid, or mastoid sinus. [17-18]

Aggressive techniques such as packing, obliteration, and cranialization of the frontal sinus is not preferred by many surgeons.[19] Literature review shows different approaches ranging from conservative till aggressive surgery especially in cases with intracranial and orbital complications. [19] Some protocols such as total nasal mucosa excision,[20,21,22] frontonasal duct obliteration, and sinus packing with autogenous fat inducing osteogenesis are very well debated. All these procedures bear advantage over conservative measures.[23]

The decision about the best time to treat and the technique employed will depend on lesion severity and extension, and a full clinical assessment of both the patient and the injury. The procedure of choice in simple and isolated injuries should be the less aggressive possible and be based on the exploration and cleaning of the surgical wound, in observing the permeability of the frontonasal duct, internal fixation of bone fragments and cosmetic appearance. In these and in more extensive and severe lesions, with intracranial involvement, the use of many associated surgical techniques is more effective and adequate, among them we mention the nasal endoscopic approach. Sinus ablation, cranialization and obliteration are procedures with increasingly more restrictive indications.

Conclusion:

The data generated from the present study concludes that fractures of the frontal sinuses are more and more frequent and serious. They involve the vital, functional and aesthetic prognosis of patients, and must therefore require a safe method of management with ways of starting allowing both good security and better exposure.

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