Original Article - Evaluative Study

Histological Diversity, Diagnostic Challenges, and Surgical Treatment Strategies of Fibrous Dysplasia of Upper and Mid-Thirds of the Craniomaxillofacial Complex

Priya Jeyaraj
Military Dental Centre (Gough Lines), Secunderabad, Telangana, India

Abstract

Background: Owing to the overlapping clinical, radiographic and histopathological features among the diverse group of Fibro-osseous lesions, a precise and definitive diagnosis of Fibrous Dysplasia (FD) can be quite challenging. Moreover, FD itself may manifest with widely varying clinical presentations, radiographic appearances and histological pictures, depending upon the maturity of the lesion, and the relative quantum of its 'fibrous' and 'osseous components'. Prompt and accurate diagnosis of Fibrous Dysplasia (FD) of the Craniomaxillofacial region is particularly important, as the condition is capable of causing considerable facial asymmetry or deformity leading even to marked disfigurement, which can have a profound psychosocial impact on the patient. Involvement of Maxillofacial bones by aggressive forms of FD, can produce serious functional debility as well, by compromising airway, breathing, vision, hearing, occlusion, mastication and mouth opening. Calvarial bone involvement can produce cranial asymmetry, and cranial base involvement can lead to persistent headaches, facial pain, numbness, and other neurological deficits owing to compression of cranial nerves. **Aims and Objectives:** To evaluate the importance of early and precise diagnosis, with prompt surgical management of these lesions, for a successful overall esthetic and functional outcome. **Materials and Methods:** A Case series of 15 patients, showcasing the principal variants of FD affecting the Craniomaxillofacial complex, namely, the Monostotic and Craniofacial forms have been described. Diversity in their Clinical, Radiographic and Histopathological presentations; their management modalities elucidating the various surgical approaches employed to access and excise these bone pathologies, have been provided along with a review of existing literature. **Results:** Various surgical approaches may be employed to access the lesions, depending upon their location, extent and involvement. Treatment protocols range from complete surgical excision to surgical shaving and recontouring, and must be decided upon on a case to case basis, with the aim to achieve the best possible esthetic and functional outcome with the least postoperative morbidity. **Conclusion:** Correlation of HPE with history, clinical features, biological behaviour, radiographic and CT appearance, laboratory findings, and intra-operative findings is imperative, so that they can be distinguished from other bony lesions and an appropriate, ideal and effective treatment modality can be instituted in time, so as to achieve the most favourable esthetic and functional outcome.

Keywords: Craniofacial fibrous dysplasia, fibro-osseous lesions, fibrous dysplasia, histopathological presentation, monostotic fibrous dysplasia

Introduction

The term "fibro-osseous lesion (FOL)" is a broad generic designation of a large and diverse group of hard tissue lesions affecting the craniomaxillofacial skeleton and other bones of the body, which are characterized by one common feature, namely, replacement of the normal bone architecture by a fibrous connective tissue (CT) matrix containing varying amounts of foci of mineralization/calcification.[1] These lesions are of varied etiology, uncertain pathogenesis and widely varying clinical, radiographic, and histopathological characteristics and range from developmental/hamartomatous anomalies, reactive and dysplastic lesions, to benign neoplasia. Precise, accurate, and definitive diagnosis of these lesions is challenging and requires a close correlation between their clinical and radiographic presentation, histopathological features, bone scans, and laboratory investigations.

Access this article online

Quick Response Code:

Website: www.amsjournal.com

DOI: 10.4103/ams.ams_219_19

Address for correspondence: Dr. Priya Jeyaraj, Military Dental Centre (Gough Lines), Opposite 1 Trg Bn AOC Centre, Trimulgherry, Secunderabad - 500 015, Telangana, India.
E-mail: jeyarajpriya@yahoo.com

How to cite this article: Jeyaraj P. Histological diversity, diagnostic challenges, and surgical treatment strategies of fibrous dysplasia of upper and mid-thirds of the craniomaxillofacial complex. Ann Maxillofac Surg 2019;9:289-314.

Fibrous dysplasia

It is a developmental/hamartomatous anomaly affecting bone maturation and remodeling, in which the normal medullary and cortical bone is replaced by disorganized and immature fibro-osseous bone, which is structurally much weaker than the former. In 1938, American pathologist Louis Lichtenstein was the first to use the term "fibrous dysplasia (FD)."[2] In 1942, Lichtenstein and Henry Lewis Jaffe described FD as a congenital anomaly caused by a disturbance of the bone-forming mesenchyme.[3] In this dysplastic disorder of bone, there exists an abnormality in osteoblast differentiation and bone-forming mesenchyme in which the maturation of bone is arrested at the immature woven type of skeletogenic maturation stage, producing abnormal, and poorly calcified bone.

This condition results from a postzygotic mutation in the Guanine Nucleotide-binding protein, α-Stimulating activity polypeptide – 1 gene.[4] This is the gene that encodes the subunit of a stimulatory G protein (GS α) located on chromosome 20.[5] As a consequence of this mutation, there is a substitution of the cysteine or the histidine amino acids of the genomic DNA in the osteoblastic cells by another amino acid, arginine. Consequently, the osteoblastic cells elaborate a fibrous tissue in the bone marrow instead of normal bone.[6] This results in the replacement of bone by excessive proliferation of cellular fibrous CT with varying amounts of irregular immature bony trabeculae.[7] The anterior craniofacial bones are more frequently involved than more lateral or posterior portions; frontal, maxillary, zygomatic, sphenoid, and ethmoid bones are more frequently involved than occipital and temporal bones.

The timing of the mutation (which could occur in the fetal or postnatal life), determines the extent and severity of bone involvement and the presence of associated abnormalities, based on which FD is classified into different types.[8] If the mutation occurs in one of the undifferentiated stem cells during early embryologic life, the osteoblasts, melanocytes, and endocrine cells that represent the progeny of that mutated cell will carry and express the mutation.[9] Hence, the same abnormality that occurs in the bone cells can also occur in the body's gland cells, leading to hormonal abnormalities and endocrine disturbances in addition to multiple bone lesions, skin darkening, cutaneous pigmentations "Café au lait spots," a condition known as McCune-Albright's syndrome. If the mutation occurs in a skeletal progenitor cell at a later stage of embryonic development, the mutated cell disperses and participates in the formation of skeleton, resulting in multiple bone involvement, a disease referred to as the polyostotic FD, also known as the Jaffe-Lichtenstein Syndrome, and if in multiple skull bones, it is referred to as craniofacial FD. If the mutation occurs during postnatal life, just a single bone is affected, referred to as monostotic FD. Another rare syndrome complex characterized by skeletal FD and intramuscular myxomas is known as the Mazabraud syndrome.[10,11]

Radiographic features

Early stage lesions

Radiolucent areas are corresponding to mark fibrous proliferation and deposition of osteoid and immature trabeculae that have yet to calcify.

Intermediate stage lesions

Areas of radiolucency with pale floccular opacifications are yielding a "mottled/moth-eaten" appearance.

Older lesions

A distinctive characteristic is varying degrees and patterns of opacification, due to the organization of the abnormal trabeculae with increased bone deposition and calcification. The abnormal bony trabeculae are usually shorter, thinner, irregularly shaped, and more numerous than normal trabeculae, creating variable radiopaque patterns.[12] The lesion may have a granular "ground-glass" appearance, resembling small fragments of a shattered windshield; a "peau d" orange' pattern, resembling the dimpled surface of an orange peel; a wispy "cotton wool" arrangement; a swirling "fingerprint" pattern; or an amorphous, homogeneous, dense, and even sclerotic appearance.[13] The nonspecific and varied radiological appearance of FD makes it difficult to differentiate from other conditions such as ameloblastic fibroma, ameloblastic odontoma, ameloblastic fibroodontoma, aneurysmal bone cyst, central giant cell granuloma, ossifying fibroma, chronic diffuse sclerosing osteomyelitis, osteoma, low-grade osteosarcoma, osteoclastoma and fibrosarcoma, and Paget's disease.[14]

A few characteristic radiographic features of craniofacial FD include blistering/bubbling cystic skull vault lesions, which commonly cross sutures; sclerotic skull base; widened diploeic space with the displacement of outer table; inner table is usually spared; and obliteration of paranasal sinuses. Pathological bone merges and blends imperceptibly with the adjacent normal bone without any distinct zone of demarcation or cortication and with no lesional delineation.[15]

Computed tomography (CT) is superior to radiography as a diagnostic tool, although alone, it too is insufficient to make a definitive diagnosis.[16] Bones affected by FD are usually expanded with an intact cortex and lose the normal corticomedullary differentiation, being replaced classically by a homogeneous ground glass appearance, although mixed lucencies and sclerosis are also common. FD presents with three characteristic patterns on CT: Ground-glass pattern (56%), homogeneously dense pattern (23%), and cystic variety (21%). Radionuclide scans, such as bone scintigraphy, have some role in the diagnosis/evaluation of FD.[17-19]

Histopathological features

The classical histological picture of FD comprises of irregularly shaped trabeculae of immature woven bone scattered in a

loosely arranged hypercellular fibrous CT stroma. They often attain curvilinear shapes which are linked to Chinese script writing.[20]

Laboratory studies

- Serum alkaline phosphatase levels are often elevated depending on the extent of bony disease, but serum calcium and phosphorus are within normal ranges[21]
- Serum calcium, phosphate, and Vitamin D levels are assessed to assist in excluding rickets
- Thyroid function tests, including triiodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH) levels, are performed to exclude hyperthyroidism
- Pituitary gonadotropins and gonadosteroids are assessed to assist in the workup of precocious puberty, to rule out McCune-Albright syndrome
- Serum alkaline phosphatase, a marker for bone turnover, and urinary hydroxyproline are useful markers, used to monitor response to nonsurgical treatment of the disease, rather than for the diagnosis of FD.

Medical therapy

No specific medical treatment exists for FD. The management usually involves observation with periodic follow-up. Any underlying endocrine disturbance, if detected, is to be treated. Vitamin D, bisphosphonates (after physeal closure) may be helpful in ameliorating pain.[22,23] Radiotherapy is contraindicated owing to high prevalence of malignant transformation.

Surgical therapy

Indications for the surgical intervention in cases of FD involving the craniomaxillofacial region include:

a. Gross facial asymmetry or disfigurement causing cosmetic/esthetic deformity[24]
b. Impending orbital encroachment or airway compromise
c. Derangement of occlusion, decreased masticatory efficiency, restricted interincisal mouth opening, and trismus
d. Risk of a pathological fracture, especially of the mandible or maxilla
e. Rapidly progressive or aggressive disease
f. Sudden enlargement in a previously quiescent lesion, with the onset of pain, suggestive of malignant degeneration
g. Other functional disabilities such as pain, paraesthesia, proptosis, or impairment of vision.

Surgical interventions may include:

a. Cosmetic osseous contouring/shaving[25]
b. Excision, curettage, and recontouring, with or without replacement of the bone defect with autograft or allograft
c. For aggressive and destructive lesions, complete surgical resection can be contemplated, followed by primary or secondary reconstruction[26]
d. Pathological fracture and associated bone deformity may require corrective osteotomy and internal fixation.[27]

Case Reports

A case series of 15 cases of FD involving the upper and mid-third of the craniomaxillofacial complex have been presented [Table 1]. The clinical, radiographic, and histological presentation, laboratory findings, and surgical management protocols employed in these cases have been compiled and described in Table 1.

Surgical interventions and therapy employed in three cases have been described in detail.

Case report 1

A 32-year-old female reported with unsatisfactory facial esthetics caused by a longstanding disfiguring protuberance and enlargement of the right malar, forehead, and temporal regions [Figure 1a-d]. The progressively increasing enlargement had first been observed during childhood; its growth had ceased at around 18 years of age; and at present, the patient sought management of the cosmetic deformity. On examination, there was observed a diffuse bony hard, nontender enlargement of the right temporal and zygomatic arch regions [Figure 1e-h]. The maxilla appeared uninvolved, and there was no derangement in occlusion. There was no interference of the movements of the coronoid process and no restriction noted in the interincisal mouth opening or in the temporomandibular joint (TMJ) movements, which were full, free, and synchronous. Ocular movements and visual acuity were within normal limits. There were no neurological deficits.

Radiographic features

On the Submentovertex/"Jughandle" view, there was seen the destruction of the normal architecture of the right zygomatic arch, which showed an expansile heterogeneously radiopaque lesion involving its root and distal half, i.e., the zygomatic process of the temporal bone almost up to the zygomaticotemporal suture. There was a moth-eaten and "cotton wool" appearance of the bony expansion in this region. The contour of the right temporal bone too appeared enlarged and protuberant.

Noncontrast CT (NCCT) and contrast-enhanced CT of the maxillofacial region [Figure 2] revealed a 4.6 cm × 3.7 cm × 5.2 cm (AP × TR × CC) expansile, mixed radiopaque-radiolucent lesion in the squamous part of the right temporal bone extending to involve the zygomatic arch. The destructive, lytic lesion exhibited interspersed areas of ground glass matrix within, with no distinct zone of transition or clear line of demarcation from the adjacent normal bone. The outer cortex appeared thinned with cortical breaches in numerous places. Anteriorly, the lesion was limited by the temporozygomatic suture; posteriorly, it involved the anterior wall of the external auditory meatus, compromising its caliber, and extended into the petrous temporal bone adjacent to the base of the styloid process; superiorly, the lesion was limited by the temporoparietal suture; the lesion encroached on the right infratemporal fossa and right middle cranial fossa with no invasion of structures in these spaces;

inferiorly, the lesion extended to the inferior most part of the temporal bone up to the articular surface of the glenoid fossa, reducing the volume of the upper joint space of the right TMJ [Figure 2]. There was no invasion of the TMJ space or middle ear cavity by the tumor. There was also no intracranial extension noted.

The differential diagnoses included benign neoplasm of the bone, giant cell lesion, FOL of the developmental/hamartomatous variety such as FD or Paget's disease. As it had been quiescent for a number of years, was restricted to one side and to a single bone, namely the temporal bone, a provisional diagnosis of monostotic FD was made. As the lesion was presently quiescent and neither progressive nor destructive and the chief complaint was impaired esthetics and facial deformity resulting from the visible expansion of the right upper third of the face; the treatment plan comprised of surgical excision of all accessible portions of the bony lesion, followed by shaving and recontouring.

Surgical procedure

The patient was operated under GA administered through oroendotracheal intubation. After local infiltration of 2%

Table 1: Clinical Presentation, Radiographic Findings, Histopathological Features and Laboratory findings, Diagnosis and Treatment Protocol employed in the 15 Cases of Fibrous Dysplasia of the Upper and Mid-third of the Craniomaxillofacial complex

Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
32 yr/F [Figure 1]	Facial asymmetry and impaired esthetics caused by a longstanding enlargement of the right cheekbone, forehead and temporal regions (Figure 1 A-D). On examination, a diffuse, non-tender bony hard expansion of the right temporal and zygomatic region (Figure 1 E-H). No neurological deficits or derangement of occlusion. TMJ movements smooth and synchronous, Normal Ocular movements and visual acuity.	An extensive expansile lytic lesion in the squamous part of the right temporal bone extending to involve the zygomatic arch up to the temporo-zygomatic suture (Figure 2 A); posteriorly, it involved the anterior wall of the External Auditory Meatus, and extended into the petrous temporal bone; superiorly, the lesion was limited by the temporo-parietal suture; the lesion encroached upon the right infratemporal fossa and right middle cranial fossa with no invasion of structures in these spaces; inferiorly, the lesion extended to the inferior most part of the temporal bone up to the articular surface of the glenoid fossa. On CECT imaging, axial and coronal sections of the lesion (Figure 2 B, C) exhibited a diffusely expansile mixed radiopaque-radiolucent lesion with interspersed areas of ground glass matrix within, with no distinct zone of transition or clear line of demarcation from the adjacent normal bone, suggestive of Fibrous dysplasia. Outer cortex appeared thinned out with cortical breaches in numerous places.	Numerous irregular, broad trabeculae of immature woven bone traversing a densely collagenous and richly fibro-cellular connective tissue stroma. Hemosiderin deposits were found scattered in the stroma. The trabeculae had numerous large osteoblasts and osteocytes and showed the presence of densely collagenous fibro-cellular islands within them (Figure 5 A-D). On greater magnification, numerous wavy, deeply staining, strongly basophilic reversal lines could be seen within the immature woven bone (Figure 5 E-H). Artifactual separation of the immature trabeculae from the fibrovascular stroma was also observed.	8	4.15	160	Monostotic Fibrous Dysplasia involving the Right Temporal bone.	Modified Blair's incision, with temporal and endaural extensions for Surgical excision of accessible portions of the lesional squamous and petrous Temporal bone (Rt), including involved segment of Zygomatic arch (Figure 3 A-L). Recontouring and smoothening. Residual defect filled with autologous fat harvested from subcutaneous layer of abdominal wall, followed by closure in layers (Figure 3 M-AB'). Postoperative recovery was smooth and uneventful with achievement of a good esthetic outcome and restoration of an ideal facial symmetry (Figure 4 A-F).

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Table 1: Contd...

Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
22 yr/M	A Prominent swelling over the forehead region, impairing facial esthetics (Figure 6 A-C). It had been present since childhood, slowly increasing in size, stabilizing thereafter, at around 16 years of age. Examination revealed a diffuse, non- tender, bony hard, ellipsoid enlargement over the glabella region of the frontal bone (Figure 6 D-F). Its margins were smooth, blending imperceptibly with the surrounding bone.	3-D Reformatted images of NCCT (Figure 6 G) showed the ellipsoid morphology of the bony enlargement involving the glabella region of the Frontal bone. The pathology appeared to be limited to this region alone, without involvement of the adjoining orbital or nasal bones, suggestive of the Monostotic variant of Fibrous dysplasia or an Osteoma. Sagittal and Axial sections (Figure 6H, I) revealed a ground glass appearance of the bony protuberance and enlargement of the outer table of the Frontal Sinus, which also encroached into the sinus cavity thereby reducing its volume.	Replacement of normal bone architecture by a richly cellular, densely collagenous, moderately vascular fibro-cellular connective tissue stroma which was richly populated with numerous uniform-appearing, spindle shaped fibroblasts (Figure 7 M-P). Within the stroma, there were numerous long, fine, slender, delicate, often branching, curvilinear trabeculae of immature woven bone. The bony trabeculae demonstrated no osteoblastic rimming, but had numerous osteoblasts and osteocytes within them. A few basophilic reversal lines were seen within some of the bony trabeculae. There was also seen artifactual separation of many of the trabeculae from the surrounding stroma (Figure 7 O, P).	8.3	4.25	110	Monostotic Fibrous Dysplasia involving the glabella region of the Frontal bone and outer table of Frontal sinus.	Bicoronal flap raised, Bony enlargement of Frontal bone exposed, margins undermined, excision completed with the help of microsaws and tungsten carbide burs, taking care not to breach the interior of the Frontal sinus (Figure 7A-L). Scalp flap replaced and closed. Excellent postoperative outcome evident both clinically (Figure 8 A-H) as well radiographically (Figure 8 I-T), with successful elimination of the protuberant bone pathology and restoration of an optimal forehead and glabellar contour.

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Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
20 yr/M	Facial asymmetry caused by a diffuse unilateral bony expansion of the right zygomatic complex (Figure 9 A-D), with an exaggerated right malar prominence, obliteration of the right nasolabial fold and elevation of the right lower eyelid as compared to its left counterpart. No pain or paresthesia in the affected area and no manifestations of partial nasal passage obstruction, such as altered resonance of speech, nasal stuffiness, mouth breathing or sleep apnea. There was no history of epiphora indicating an absence of obstruction of the nasolacrimal apparatus.	Diffuse expansion of the Zygomatic complex and Temporal bone on the right. There was seen an increase in bulk and contour of the right zygomatic arch, body of zygoma and thickening of the zygomatic buttress region and the lateral wall of the orbit (Figure 9 E, F). The involved bone had a granular, "ground-glass" appearance with indistinct margins which blended with the adjacent normal appearing bone. Axial sections revealed opacification of the base of the skull in the region of the middle cranial fossa (Figure 9 G, H). There was contiguous involvement of the basisphenoid, greater and lesser wings of sphenoid including the sella turcica, the zygomatic body and arch on the right side.	Numerous broad, irregularly shaped trabeculae of immature woven bone in a scanty fibrocellular connective tissue stroma (Figure 12 A-D). Higher magnification showed the haphazardly oriented trabeculae which contained a few basophilic reversal lines, plump osteoblasts and osteocytes (Figure 12 E-H). The CT stroma contained a moderate number of fusiform, spindle-shaped fibroblasts and scattered hemosiderin deposits.	10	3.95	140	Craniofacial Fibrous Dysplasia with Polyostotic involvement of multiple bones, namely, the Temporal bone, zygomatic complex and contiguous bones of the cranial base.	Al Quayat-Bramley approach (Figure 10A-D) employed to expose the zygomatic arch, body and accessible portions of the temporal bone, which were reduced in bulk and thickness using vulcanite trimmers. Anterolateral wall of maxilla and the zygomatic body and buttress exposed using an intraoral upper buccal sulcus approach (Figure 10E). The bony pathology excised (Figure 10F-H), followed by shaving and contouring of the expanded bone. Resulting bony defect packed with a mixture of fresh autologous Platelet rich fibrin (PRF) and Hydroxyapatite & Tricalcium Phosphate bone graft substitute granules (Figure 10 I-L), prior to closure. (Figure 11 A-D) There was good postoperative healing with an excellent restoration of facial symmetry and esthetics. (Figure 11 E, F) Postoperative radiographs confirmed achievement of a symmetrical contour of the mid-third of the facial skeleton.

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Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
72/F	A longstanding swelling above right eye, which had lately become painful to touch and caused some discomfort on looking up. A prominent bony expansion of the right supraorbital ridge and orbital roof (Figure 13 A-C) seen as an ovoid protuberance causing displacement of the upper eyelid downwards, resulting in a droop, with obliteration of the supratarsal crease. Visual acuity, ocular movements, corneal and pupillary reflexes were within normal limits. There was no proptosis, ophthalmoplegia or diplopia.	A diffuse expansion of the right fronto-orbito-zygomatic complex, involving the supraorbital ridge, orbital roof and body of zygoma. The bone in this region appeared sclerotic exhibiting a typical "ground glass" radio-opacity, and gradually blended with the adjacent bone without any delineating borders or margins.	Mature lesion of fibrous dysplasia, with broad, wavy trabeculae of lamellar bone arranged in a haphazard array (Figure 13 Q, R). The typical feature of "Chinese-letter" pattern of trabeculae of woven bone was not seen, but rather broad, elongated trabeculae of lamellar bone were abundant, containing a few basophilic reversal lines. The fibrovascular connective tissue stroma had a moderate number of fusiform, spindle-shaped fibroblasts (Figure 13 S, T).	8.5	3.5	60	Craniofacial dysplasia involving bones of the Fronto-orbital complex.	A lateral eyebrow approach with a crow's foot extension was employed to expose the bony swelling (Figure 13 D-F). The overhanging ovoid protuberance on the anterior aspect of the orbital roof was first excised, followed by excision of the bony bulge over the supraorbital ridge and frontal bone (Figure 13 G-J). Vulcanite trimmers used to smoothen the excised margins following the contour excision (Figure 13 K, L). Closure of the surgical site.
18yr/F	Slow growing, longstanding, painless bony swelling of the left side of the face in the region of the maxilla obliterating the nasolabial fold (Figure 14 A). Intraoral examination revealed expansion of the buccal cortical plate in the region of left upper quadrant, without displacement of teeth. Palatal bone uninvolved.	Bony enlargement with a diffuse 'ground glass" opacification involving the left maxilla, causing expansion of the buccal cortical plate and completely obliterating the maxillary antrum on the left side (Figure 14 B-E). Nasal cavity on the left reduced in volume. Palatal, Orbital and Zygomatic bones uninvolved.	Moderately dense fibrovascular CT matrix containing numerous scattered irregular trabeculae of immature woven bone (Figure 14 L, M).	9	3	60	Monostotic FD of the left maxilla and maxillary antrum.	Intraoral vestibular approach to expose the expanded maxilla. Excision of soft, gritty pathological bony tissue, followed by extirpation of the antral lining, curettage and contouring of remaining bony edges (Figure 14 F-H). Post op CT (Figure 14 I-K).

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Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
15yr/F	Facial asymmetry caused by a diffuse expansion of the right maxilla, with obliteration of both, the nasolabial sulcus as well as the naso-facial sulcus on the affected side (Figure 15 A, B). Insidious onset of the slow growing, painless bony swelling, which was first noticed 3 years ago. No complaints of nasal stuffiness or difficulty in breathing. No evidence of neural involvement or neurological deficits such as paraesthesia, pain or tenderness. Ocular movements and visual acuity within normal limits.	Radiographs and NCCT scans revealed a diffuse opacification of the Rt Maxillary antrum, which demonstrated a homogeneous 'ground glass' appearance typical of a fibro-osseous lesion such as Fibrous dysplasia (Figure 15 F). There was almost complete obliteration of the right maxillary antrum by the pathology.	Haematoxylin & Eosin sections showed a dense fibro-cellular CT matrix containing numerous scattered irregular, branching, Chinese letter shaped, and even spherule shaped trabeculae of immature woven bone (Figure 15 G-J).	9.3	4.5	55	Monostotic FD of the right maxilla and maxillary antrum.	Exposure of the lesion via an intraoral vestibular approach, surgical excision and curettage carried out followed by bony recontouring (Figure 15 C-E).
27 yr/M	Facial asymmetry and deformity caused by prominent enlargement of the left zygomatico-maxillary complex (Fg 16 A-F).	CBCT scan performed with Newtom Giano scanner at resolution (0.09mm x 0.09mm x 0.09mm) revealed an expansile, diffuse and poorly defined bony lesion measuring approx. 3.6cm x 3.3cm x 3.8cm in antero-posterior, transverse and supero-inferior dimensions, in the region of the left maxilla (Figure 16 G-K). The mixed density lesion with diffuse trabecular effacement and islands of condensed or mildly sclerotic trabeculae, involving the left zygomatico-maxillary complex, basal and alveolar process of the left posterior maxilla, obliterating the left maxillary sinus. The lesion was characterised by a ground glass texture with indistinct, fuzzy transition zones, suggestive of a benign, non-odontogenic mixed density lesion, most likely, fibrous dysplasia.	Haphazardly oriented broad, immature bony trabeculae which contained a few deeply staining, basophilic reversal lines, plump osteoblasts and osteocytes (Figure 17 E-H). The CT stoma contained a moderate number of fusiform, spindle-shaped fibroblasts.	9	5	65	Craniofacial FD with contiguous involvement of the left Maxilla and body of Zygoma.	Surgical excision followed by contour shaving and smoothening was carried out via an intraoral upper vestibular approach (Figure 17 A-D). Excised specimen had a gritty consistency, softer than normal bone.

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				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
23yr/M	A large, localised, dome shaped swelling measuring approximately 7 x 6 x 3 cm on the right side of the head extending from the region of the coronal suture, and involving the forehead to the right supraorbital rim and bridge of the nose. diffuse borders which blended imperceptibly with the surrounding normal appearing bone of the forehead. All neurological examinations were unremarkable.	A diffuse radio-opaque thickening of the outer cortical table of the frontal bone, on the right side, extending from the coronal suture region down to the supra-orbital rim and bridge of the nose. The enlargement was dome shaped and the radio-opaque mass exhibited a "Ground glass" appearance. The diploeic space in this region appeared hazy and enlarged. The findings were consistent with a Right sided frontal osteoma or Fibrous dysplasia.	Replacement of normal bone architecture by whorls of densely cellular fibrous connective tissue stroma interspersed with elongated branching trabeculae of immature woven bone with numerous osteoblasts within.	8	4.15	40	Craniofacial FD, with contiguous involvement of the Frontal, orbital and nasal bones.	Bicoronal approach for marginal resection and debulking of the bony mass with surgical recontouring of the frontal bone under General anaesthesia. Osteotomes were used to resect the lesional bone in layers, till the dome shaped bulge in the region was eliminated. Recontouring and finishing was completed using vulcanite trimmers under copious saline irrigation.
28yr /F	Longstanding, painless, progressive enlargement of the left cheekbone, causing some difficulty in looking up. O/E, a large fusiform bony hard enlargement of the body of the zygoma, with upward expansion of the infraorbital rim.	Diffuse, fusiform radiopaque enlargement of the zygoma, with a typical 'ground glass' appearance. The borders of the enlargement were not distinct, but blended imperceptibly with the surrounding normal bone.	Numerous, delicate, curvilinear, branching bony trabeculae of immature woven bone in a dense fibrocellular connective tissue matrix. Scattered hemosiderin deposits were found.	9.5	3.95	50	Monostotic Fibrous Dysplasia involving left Zygomatic bone.	An intraoral buccal sulcus approach used to expose the bony expansion of the body and buttress of the zygoma. Contour excision carried out with microsaws, followed by trimming and smoothening of the edges with vulcanite trimmers under copious saline irrigation.
17yr/M [Figure 6]	Facial asymmetry and deformity caused by frontal bossing on the left side, with enlargement of the frontal bone extending posteriorly up to the coronal suture and anteriorly up to the supraorbital ridge. Bony swelling associated with complaint of pain in the region.	Large ovoid, radiopaque bony enlargement involving the left side of the frontal bone. Typical 'cotton wool' appearance of the involved bone which merged with the surrounding apparently normal bone.	Numerous broad, irregularly shaped trabeculae of immature woven bone in a scanty fibrocellular connective tissue stroma. Higher magnification showed the haphazardly oriented trabeculae which contained a few basophilic reversal lines, plump osteoblasts and osteocytes.	9.5	3.85	85	Monostotic Fibrous Dysplasia, involving the Frontal bone on the left side.	Contour excision via a Bicoronal approach. Bone was of a gritty softer consistency than normal bone. Shaving of the bony excess carried out to achieve a symmetrical cranial contour. Smoothening carried out with vulcanite trimmers under saline irrigation followed by scalp flap closure.

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Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
27 yr/M	Facial asymmetry and impaired esthetics caused by a painless, slow growing expansion of the left maxillary region, involving the palate as well as buccal cortical plate. Dental arches and Occlusion unaffected.	Loss of lamina dura around teeth of the upper left quadrant; homogeneous, granular, 'ground glass' radio-opaque pattern in the periapical areas and the left maxillary alveolar bone with expansion of buccal and palatal cortical plates. Obliteration of the left maxillary antrum by the granular radiopacity. Nasal cavity not encroached by the bony growth.	Thin, delicate, branching trabeculae and small spherules of immature woven bone dispersed in a richly cellular fibrous connective tissue stroma. A number of osteoblasts identifiable within the trabeculae, however without any osteoblastic rimming.	9	4.15	40	Monostotic Fibrous Dysplasia involving the left Maxilla.	Contour shaving of the excess bone of the anterolateral wall of the left maxilla carried out via an intraoral upper buccal sulcus approach. Palatal expansion left unaddressed as asymptomatic.
39yr/F	Facial asymmetry and deformity caused by bony enlargement of mid-third of the face on the left side. Left maxilla, body of zygoma, temporal and frontal processes of zygomatic bone, infraorbital rim as well as lateral wall of orbit involved by the expansile bony pathology. Paraesthesia in the left upper cheek and lip.	A wispy 'cotton-wool' like homogeneous radiopacity involving the left Zygomatic bone and Maxilla, with obliteration of the left maxillary antrum. Loss of normal bony architecture with replacement of the normal trabecular pattern of bone with swirling, 'finger-print' like patterns.	Short, 'Chinese letter pattern' like trabeculae of immature woven bone in a densely collagenous fibrocellular connective tissue stroma. Numerous osteoblasts present within the trabeculae.	8.5	4	50	Craniofacial Fibrous Dysplasia with contiguous involvement of Zygomatico-orbito-maxillary complex.	Contour excision and shaving of bony enlargement via a combination of Extraoral and Intraoral approaches, namely the Al Quayat & Bramley's modified preauricular approach for the Zygomatic bone and arch, and an intraoral vestibular approach for the maxilla and zygomatic buttress.
35yr/M	Longstanding, painful, progressive enlargement of the left cheekbone. O/E, a large fusiform bony hard enlargement of the body of the zygoma, with expansion of the infraorbital rim. Pain and paraesthesia in the region supplied by the Infraorbital nerve, indicative of nerve compression within its foramen	Diffuse, homogenously radiopaque enlargement of the zygoma, with a typical 'ground glass' appearance. The borders of the enlargement were not distinct, but blended imperceptibly with the surrounding normal bone.	Numerous, delicate, curvilinear, branching bony trabeculae of immature woven bone in a moderately dense fibrocellular connective tissue matrix.	10.5	4.95	65	Monostotic Fibrous Dysplasia involving left Zygomatic bone.	Intraoral buccal sulcus approach used to expose the bony expansion of the body and buttress of the zygoma. Contour excision with microsaws, followed by trimming, shaping and smoothening of the remaining bone.

Contd...

Table 1: Contd...

Age/ Sex	Clinical Presentation	Radiographic and NCCT Findings	Histopathological Features	Laboratory Findings			Diagnosis	Surgical Approach & Management Protocol Employed
				Ca++ (mg%)	P+++ (mg%)	Alk Phos (IU/L)		
19 yr/F	Slowly progressive enlargement of the right side of the mid-third of the face, first noticed 3 years ago. O/E, bony protuberance of the right malar complex and overhanging of the alveolar bone in the right upper quadrant, evident intraorally.	A mixed density, radiopaque-radiolucent lesion with diffuse trabecular effacement and islands of condensed or mildly sclerotic trabeculae, involving the right zygomatico-maxillary complex, basal and alveolar process of the right posterior maxilla, partially obliterating the right maxillary sinus.	Small, irregular, curvilinear, branching trabeculae of immature woven bone, scattered in a fibrous connective tissue matrix. Sparse areas of lamellar bone interspersed amidst the haphazardly arranged woven bone.	8.5	3	85	Craniofacial FD involving the right Zygomaticomaxillary complex.	An extended Upper buccal sulcus approach employed to expose the pathology, followed by contour excision and remodelling of the bone. Malar prominence reduced considerably via the intraoral approach, with a good esthetic outcome.
22 yr/M	Diffuse unilateral bony expansion of the right zygomatico-maxillary complex, with obliteration of the right nasolabial fold. The right lower eyelid appeared to be elevated as compared to its left counterpart. Exaggerated right malar prominence and an outward expansion of the right zygomatic arch as well. pain or paresthesia in the entire region of the bony expansion and in the area supplied by the right Infraorbital nerve.	Increase in bulk and contour of the right zygomatic arch, body of zygoma and thickening of the zygomatic buttress region. The involved bone appeared to have a granular, "ground-glass" like texture and indistinct margins which blended with the adjacent normal appearing bone. There was partial obliteration and a diffuse opacification of the right maxillary antrum. The nasal septum appeared to deviate to the left. Axial sections of CT scan revealed a typical "ground glass" opacification of the base of the skull in the region of the middle cranial fossa, with contiguous involvement of the basisphenoid, greater and lesser wings of sphenoid, the zygomatic body and arch, and maxilla on the right side. A full body scintigraphy was done using Technetium bone scan, which revealed hot spots in the involved right zygomatico-maxillary complex region.	Replacement of normal bone architecture by a richly cellular, densely collagenous moderately vascular fibrocellular connective tissue stroma. Within the stroma, were numerous long, fine, slender, delicate, often branching, curvilinear trabeculae of immature woven bone. The bony trabeculae had numerous osteoblasts and osteocytes within them, and also exhibited a distinct osteoblastic rimming.	9	4	99	CraniofacialFD involving multiple bones of the Craniofacial complex and skull base.	Contour excision of the right zygomatico-maxillary region via Al Quayat-Bramley modified Preauricular and Temporal approach.

(Normal Values of Serum Calcium = 8-10 mg/dl, Phosphorus = 2.5-4.5 mg/dl and Alkaline Phosphatase = 20-130 IU/ L)

Figure 1: (Case 1) (a-h) A 32-year-old female patient with facial asymmetry and impaired esthetics caused by a longstanding enlargement of the right cheekbone, forehead, and temporal regions. On examination, a diffuse, nontender bony hard expansion of the right temporal and zygomatic region was noted. There were no neurological deficits or derangement of occlusion. The temporomandibular joint movements were smooth and synchronous; ocular movements and visual acuity were normal

lignocaine with 1:100,000 adrenaline along the proposed incision line, a modified Blair incision was placed with temporal and endaural extensions [Figure 3a]. Dissection was carried out superficial to the temporoparietal and Parotid fascia (SMAS/ Superficial Musculoaponeurotic System), taking care to preserve the branches of the facial nerve [Figure 3b]. Oblique incision was made through the superficial layer of the temporal fascia and dissection carried out to expose the zygomatic arch [Figure 3c]. The temporalis muscle was elevated, exposing the squamous part of the temporal bone. The bony expansile lesion involved the root of the arch, extended upward up to involve the lower aspect of the squamous part of the temporal bone, and downward to overhang the TMJ and condylar regions. The bony lesion was exposed and stripped of its periosteal cover [Figure 3c and d]. The entire involved sections of the zygomatic arch and temporal bone were sectioned and excised using micro saws, and vulcanite trimmers were used to trim away the rest of the bony lesion and to contour and smoothen the remaining bone [Figure 3e-g]. The lesional bone was soft and spongy in texture and easily cleaved away from the adjacent normal bone [Figure 3h]. On removal of the entire pathology, the articular disc and condyle was exposed to view. Hemostasis was achieved. The defect resulting after the removal of the bony pathology was filled with fresh autologous fat harvested (approximately 30 cc) from the subcutaneous layer of the patient's abdominal wall [Figure 3m-w]. The closure was accomplished in layers, using Vicryl sutures for the deeper layers and prolene for the skin [Figure 3x-z and AA']. An extraoral pressure dressing was applied to limit the postoperative edema and swelling [Figure 3AB']. Postoperative recovery was smooth and uneventful [Figure 4a-c]. The patient was placed under antibiotic cover for 5 days, during which time analgesics were also prescribed. At 2 months' postoperative, a good esthetic outcome was achieved with the restoration of an ideal facial symmetry [Figure 4d-f].

Histopathological features

Histopathological examination of the excised specimen [Figure 5] revealed numerous irregular, broad trabeculae of immature woven bone traversing a densely fibrocellular CT stroma. The trabeculae had numerous large osteoblasts and osteocytes [Figure 5a-d]. Tiny lacunae were also evident. Hemosiderin deposits were found scattered in the CT stoma. The broader trabeculae showed the presence of densely collagenous fibro-cellular islands within them. On greater magnification, numerous wavy, deeply staining, strongly basophilic reversal lines could be seen within the immature woven bone [Figure 5e-h]. Artifactual separation of the immature trabeculae from the fibrovascular stroma was also observed [Figure 5i-l].

Postoperative review

On late postoperative (18 months' following surgery) review of the patient, CT scans revealed a satisfactory remodeling of the temporal bone with no evidence of recurrence or extension of the bone pathology. The good esthetic results of the surgery were maintained.

Case report 2

A 22-year-old male patient reported with a prominent swelling over the forehead region, impairing facial esthetics [Figure 6a-c]. It had been present since childhood, slowly increasing in size, stabilizing thereafter at around 16 years of age. The examination revealed a diffuse, nontender, bony

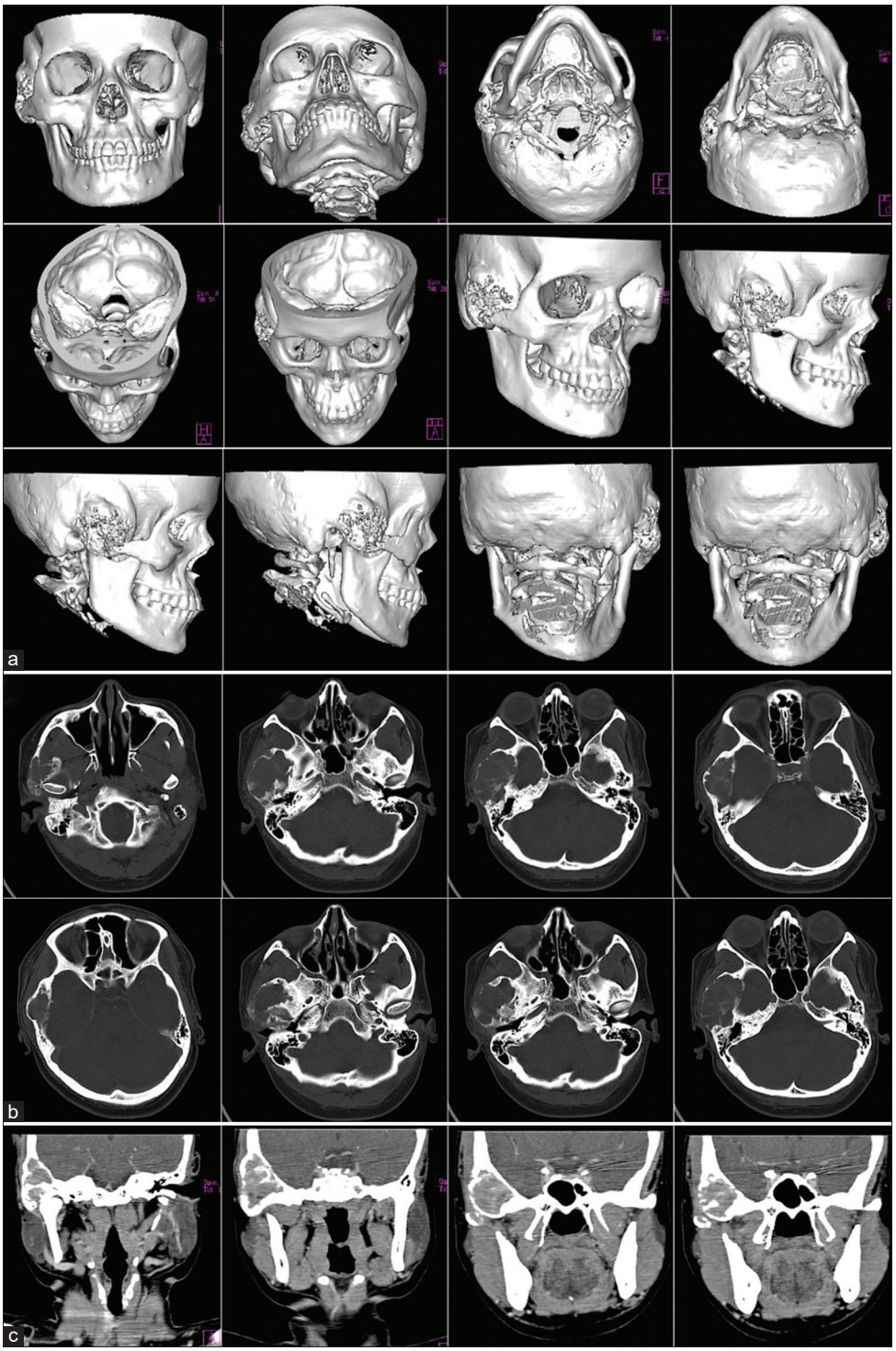

Figure 2: (Case 1) (a) Noncontrast computed tomography revealed a 4.6 cm × 3.7 cm × 5.2 cm (AP × TR × CC) expansile lytic lesion in the squamous part of the right temporal bone extending to involve the zygomatic arch. It encroached on the right infratemporal fossa and middle cranial fossa with no invasion of structures in these spaces. (b and c) On contrast-enhanced computed tomography imaging, the lesion exhibited mixed radiopaque-radiolucent appearance, with no distinct zone of transition from the adjacent normal bone, suggestive of fibrous dysplasia. Outer cortex appeared thinned out with cortical breaches in numerous places

hard, ellipsoid enlargement over the glabella region of the frontal bone [Figure 6d-f]. Its margins were smooth, blending imperceptibly with the surrounding bone. Three-dimensional reformatted NCCT images of the craniomaxillofacial region [Figure 6g] showed the ellipsoid morphology of the bony enlargement involving the glabella region of the frontal bone. The pathology appeared to be limited to this region alone, without the involvement of the adjoining orbital or

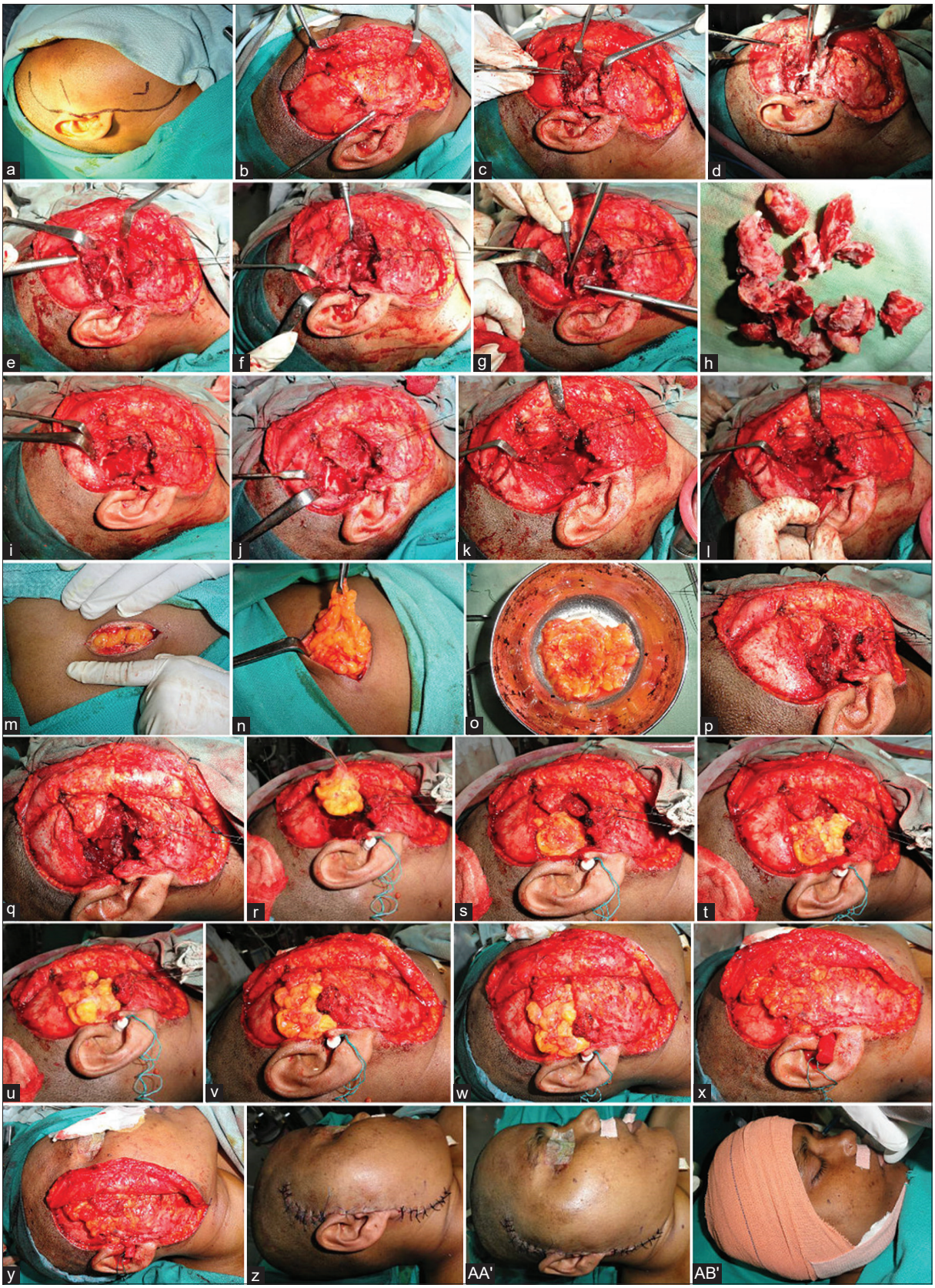

Figure 3: (Case 1) (a) Modified Blair's incision. (b) Dissection carried in a plane superficial to the temporoparietal and parotid fascia (SMAS Fascia), preserving branches of the facial nerve. (c) Bulbous bony lesion involving root of zygomatic arch and temporal bone, exposed. (d-h) Lesional bone removed. (i-l) Large defect remaining after the removal of bony pathology. (m-o) Autologous fat harvested from the subcutaneous layer of the abdominal wall. (p-w) Harvested fat graft used to fill the large defect. (x-z and AA' and AB') Layer wise closure completed followed by an external pressure dressing

nasal bones, suggestive of the monostotic variant of FD or an osteoma. Sagittal and axial sections [Figure 6h and i] revealed a ground-glass appearance of the bony protuberance and enlargement of the outer table of the frontal sinus, which also encroached into the sinus cavity thereby reducing its volume. Serum calcium and phosphorus levels were within normal limits, while the serum alkaline phosphatase level was raised.

On correlating the history, clinical and radiographic presentation, a differential diagnosis of a benign neoplasm such as osteoid osteoma, osteoblastoma, or a FOL, most likely, monostotic FD of the frontal bone was made. The laboratory finding of increased serum alkaline phosphatase was suggestive of the latter. The patient was taken up for the excision of the lesion and recontouring the bone, under GA [Figure 7a-l].

Figure 4: (Case 1) (a-c) A smooth and uneventful postoperative recovery with good healing of the operated site. (d-f) Achievement of a good esthetic outcome at 2 months' postoperative, with the restoration of an ideal facial symmetry

A full-thickness bicoronal flap was raised in the subpericranial plane, exposing the bony enlargement of the anterior aspect of the frontal bone. Chisels and osteotomes were used to section the bony pathology out, followed by contouring and smoothening of the remaining bony surface with vulcanite trimmers. Care was taken neither breach or exposes the sinus cavity space [Figure 7a-l]. The scalp flap was replaced, and closure completed after the placement of a vacuum-assisted closed suction drain. The postoperative recovery was smooth with no early or late complications [Figure 8], with an excellent esthetic outcome and restoration of a normal forehead shape and contour.

Histopathological examination of the excised bony tissue [Figure 7m-p] revealed the replacement of normal bone architecture by a richly cellular, densely collagenous, moderately vascular fibrocellular CT stroma, which was richly populated with numerous uniform-appearing, spindle-shaped fibroblasts. Within the stroma, there were numerous long, fine, slender, delicate, often branching, curvilinear trabeculae of immature woven bone. The bony trabeculae demonstrated no osteoblastic rimming but had numerous osteoblasts and osteocytes within them. A few basophilic reversal lines were seen within some of the bony trabeculae. There was also seen the artifactual separation of many of the trabeculae from the surrounding stroma [Figure 7o and p].

Case report 3

A 20-year-old male patient reported with the chief complaint of an unsatisfactory facial appearance [Figure 9a-d] caused by a

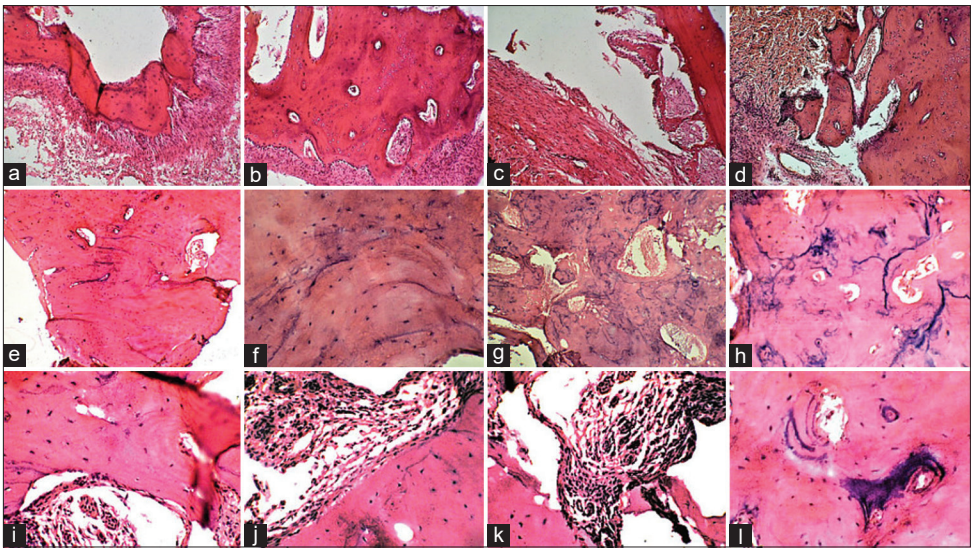

Figure 5: (Case 1) Hematoxylin and eosin-stained sections at ×40 and ×100. (a-d) Irregular, broad trabeculae of immature woven bone traversing a densely cellular fibrocollagenous connective tissue stroma. Numerous large osteoblasts and osteocytes were seen within the trabeculae, no osteoblastic rimming observed along the trabecular margins. (e-h) Numerous wavy, deeply staining, strongly basophilic reversal lines could be seen within the immature woven bone. (i-l) Artifactual separation of the trabeculae from the surrounding connective tissue stroma was observed

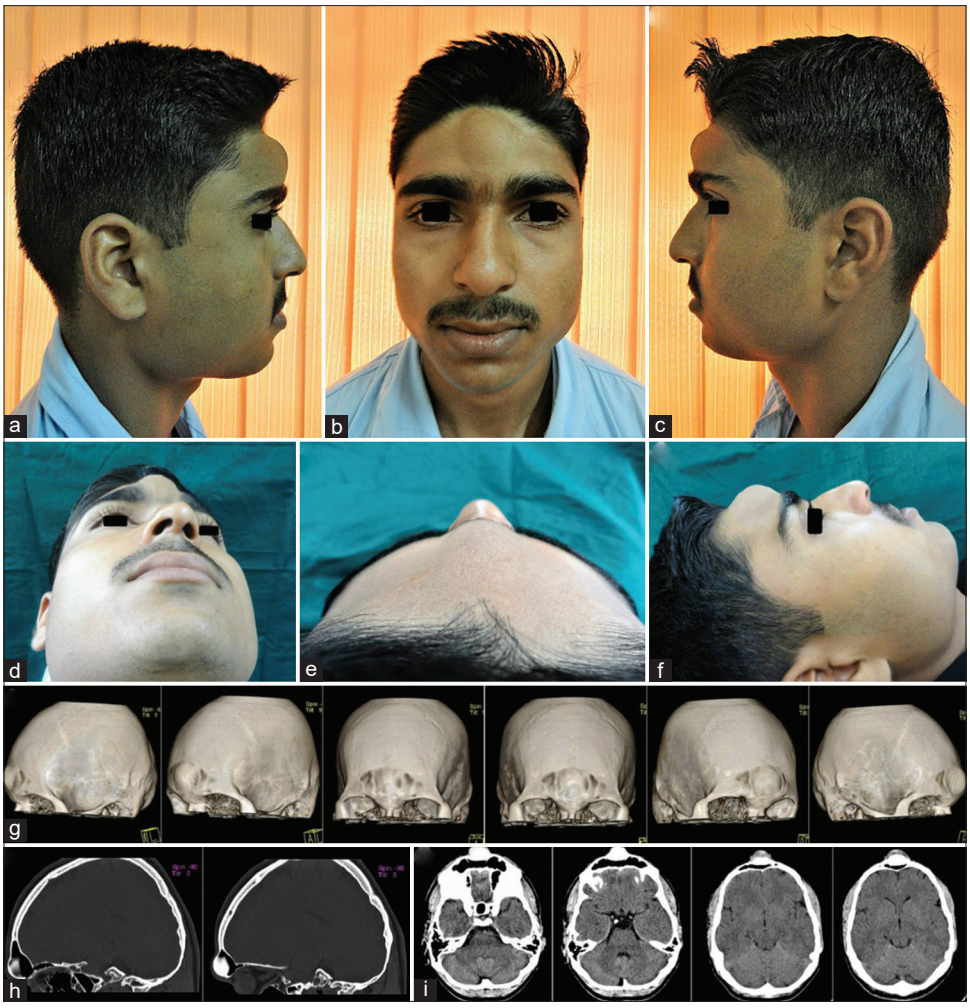

Figure 6: (Case 2) (a-f) Prominent, bony hard, nontender swelling with smooth margins over the forehead region. (g) Noncontrast computed tomography showed the ellipsoid morphology of the bony enlargement involving the glabella region, without the involvement of the adjoining orbital or nasal bones, suggestive of the monostotic variant of fibrous dysplasia or Osteoma. (h and i) Sagittal and axial sections revealed a ground-glass appearance, with enlargement of the outer table of the frontal sinus, encroaching into the sinus cavity thereby reducing its volume

swelling in the region of his right cheekbone. History revealed that the swelling had been present through childhood, slowly increasing in size and persisting into adolescence. There was no pain or paresthesia in the affected area and no manifestations of partial nasal passage obstruction, such as altered resonance of speech, nasal stuffiness, mouth breathing, or sleep apnea. There was no history of epiphora indicating an absence of obstruction of the nasolacrimal apparatus.

On examination, the patient exhibited an obvious facial asymmetry caused by a diffuse unilateral bony expansion of the right zygomatic complex [Figure 9a and b]. There was obliteration of the right nasolabial fold, and the right lower eyelid appeared to be elevated as compared to its left counterpart. The exaggerated right malar prominence was even more obvious from the bird's eye view and worm's view positions [Figure 9c and d]. The bony expansion was smooth and diffused with normal overlying skin. The inter-incisal mouth opening, temporomandibular movements, and occlusion were all normal, and there was no displacement of the maxillary teeth seen. The differential diagnosis included a benign FOL, osteoma, etc.

Radiographs (paranasal sinus and submentovertex views) [Figure 9e] and CT scans (coronal sections) [Figure 9f] revealed a diffuse expansion of the zygomatic complex and temporal bone on the right. There was seen an increase in bulk and contour of the right zygomatic arch, body of zygoma, and thickening of the zygomatic buttress region and the lateral wall of the orbit. The involved bone had a granular, "ground-glass" appearance with indistinct margins, which blended with the adjacent normal-appearing bone. Axial sections [Figure 9g and h] revealed a "ground glass" opacification of the base of the skull in the region of the middle cranial fossa. There was contiguous involvement of the basisphenoid, greater and lesser wings of sphenoid, including the sella turcica, the zygomatic body, and arch on the right side.

Laboratory investigations, namely, serum calcium, phosphorus, and alkaline phosphatase, were all within normal limits. T_3, T_4,

Figure 7: (Case 2) (a-h) Bicoronal flap raised in a sub-pericranial plane, exposing the bony enlargement of anterior aspect of frontal bone. (i-k) Sectioning of pathology followed by contouring and smoothening. (l) Closure completed. (m-p) Hematoxylin and eosin sections at ×10, ×40 and ×100, showing delicate, branching, curvilinear trabeculae ("Chinese letter pattern") of immature woven bone, scattered in an abundant and richly cellular fibro collagenous connective tissue stroma. Numerous plump, spindle-shaped osteoblasts observed within the trabeculae of woven bone

and TSH levels were checked to rule out endocrinopathies, a possible feature of the McCune-Albright's syndrome. A full body scintigraphy was done using Technetium (^{99m}Tc-MBP) whole-body bone scan, and a single-photon emission-CT (SPECT) study of skull bones was carried out, which revealed hot spots indicative of polyostotic involvement of multiple skull bones on the right side. There was no involvement of the rest of the skeleton. A provisional diagnosis of craniofacial FD was made correlating the clinical presentation with the radiographic and CT, SPECT, and technetium scan findings.

The patient was taken up for surgery under GA for contour excision of the right zygomaticomaxillary region to restore the facial symmetry and esthetics [Figure 10].

An Al Quayat–Bramley approach [Figure 10a-d] was employed to expose the zygomatic arch and body, which were reduced in bulk and thickness using vulcanite trimmers. The anterolateral wall of the maxilla and the zygomatic body and buttress were exposed using an intraoral buccal sulcus approach [Figure 10e]. The bony pathology was excised [Figure 10f-h], followed by shaving and contouring of the

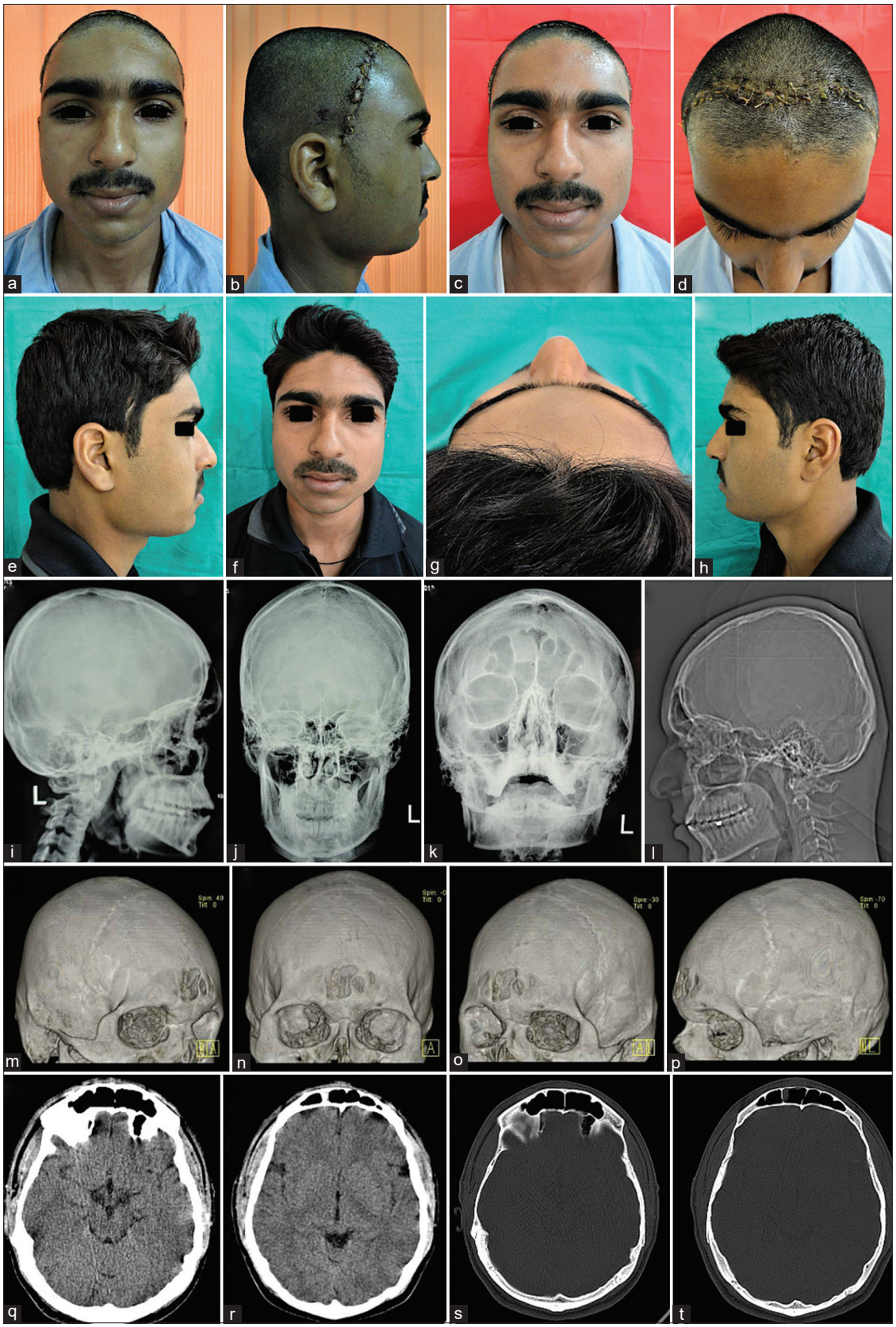

Figure 8: (Case 2) (a-d) Appearance on the 4th postoperative day, showing good restoration of the cranial contour and facial esthetics. (e-h) One-year postoperative appearance showing no evidence of recurrence or progression of the lesion. The bicoronal incision scar was camouflaged well within the hairline. (i-l) Lateral, posteroanterior, and occipitomental view radiographs and (m-t) noncontrast computed tomography of craniomaxillofacial region taken postoperatively, showing successful removal of the protuberant bone pathology from the glabella region and restoration of its normal contour

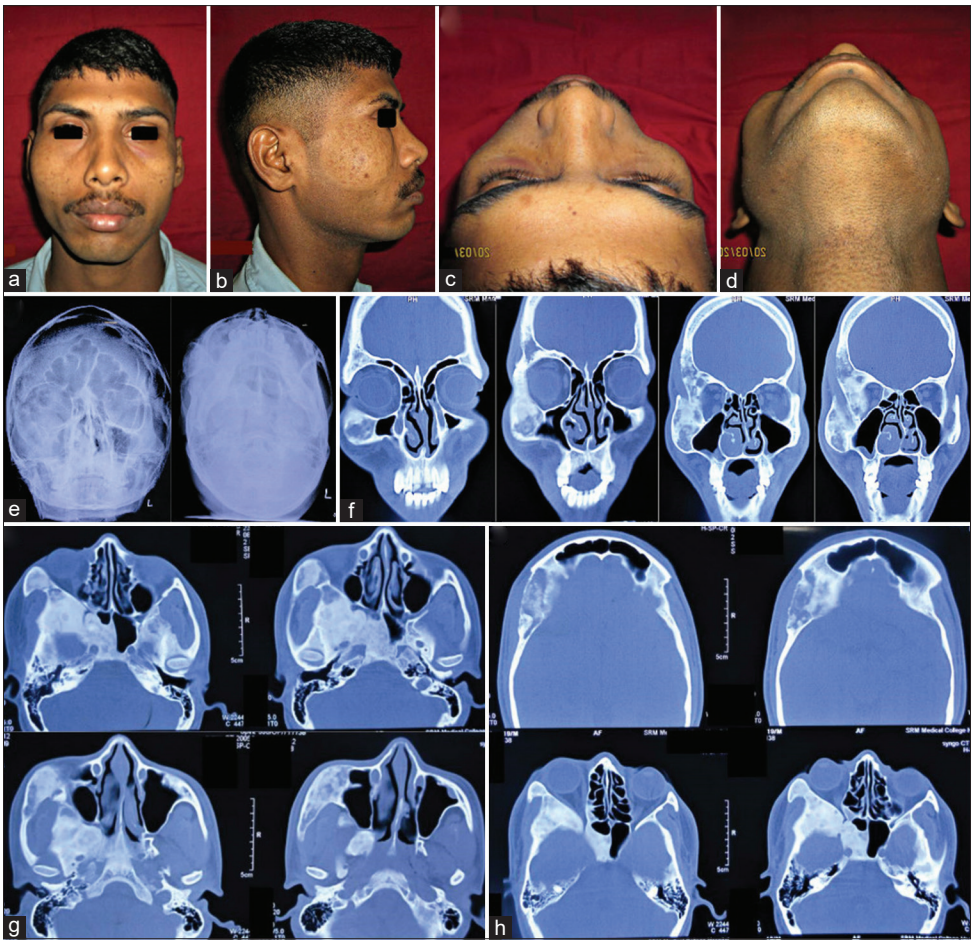

Figure 9: (Case 3) (a-d) Facial asymmetry caused by a bony enlargement of the mid-third of the face on the right. (e) Radiographs showing a diffuse opacified expansion of Rt Zygomatic complex. (f) Noncontrast computed tomography demonstrating diffuse expansion of the zygomatic complex and temporal bone, which had a granular, "ground-glass" appearance with indistinct margins which blended with the adjacent normal-appearing bone. (g and h) Opacification of the base of the skull in the region of the middle cranial fossa, contiguous involvement of the basisphenoid, greater and lesser wings of sphenoid including the sella turcica

expanded bone. The resulting bony defect was packed with a mixture of fresh autologous platelet-rich fibrin (PRF) and hydroxyapatite and tricalcium phosphate bone graft substitute granules [Figure 10i-k]. Layer-wise closure was carried out after ensuring adequate hemostasis [Figure 10l]. Postoperative healing was smooth and uneventful, and excellent cosmetic results were achieved [Figure 11a-d]. Postoperative radiographs confirmed the achievement of a symmetrical contour of the mid-third of the facial skeleton [Figure 11e and f].

Histopathological examination of the excised bony specimen [Figure 12a-d] revealed numerous broad, irregularly shaped trabeculae of immature woven bone in a scanty fibro cellular CT stoma, which contained a moderate number of fusiform, spindle-shaped fibroblasts and scattered hemosiderin deposits. The broad bony trabeculae exhibited a few basophilic reversal lines, plump osteoblasts, and osteocytes [Figure 12e-h].

The clinical, radiographic, and histological presentation, laboratory findings and surgical management protocol employed in all the 15 cases in this series have been compiled and described in Table 1.

Discussion

FOLs of the craniomaxillofacial bones represent a diverse group of pathologic conditions, which may be developmental, reactive, dysplastic, or neoplastic but are grouped together owing to similarities in their histopathological appearance.[1] Adding to their differential diagnoses, are numerous other bone pathologies affecting this region that clinically, radiologically, and microscopically resemble the FOLs.[28]

In spite of their overlapping microscopic features, the origin, etiology, nature, clinical behavior, response to medical and surgical management, and prognosis of each of these lesions is quite different, so their management modalities and treatment options differ as well.[29] Hence, an accurate diagnosis is imperative, which involves carefully correlating all aspects

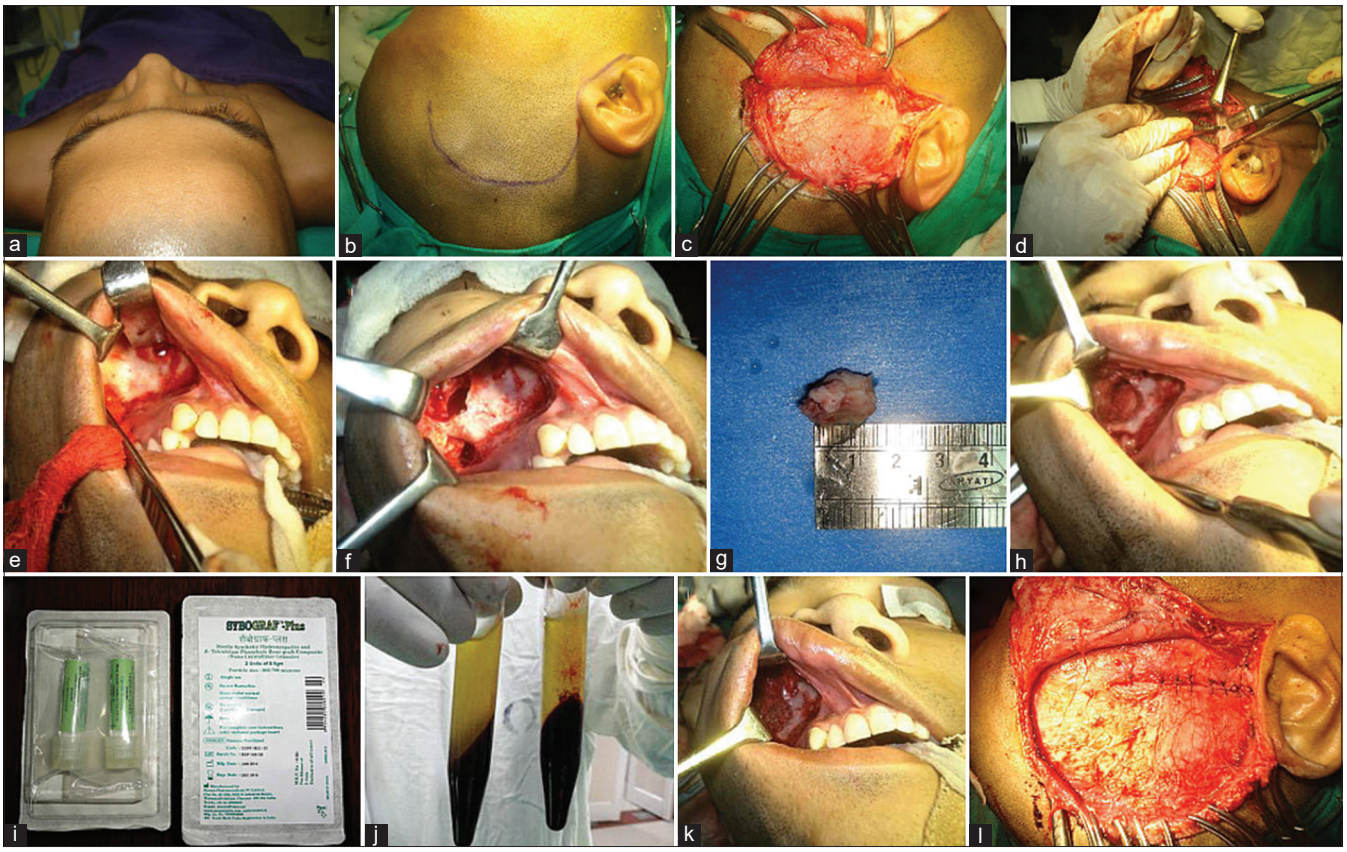

Figure 10: (Case 3) (a-d) An Al Quayat-Bramley temporal to expose the zygomatic arch and body and accessible portion of the temporal bone (Rt), which were reduced in bulk and thickness. (e-h) Anterolateral wall of the maxilla and zygoma exposed using an intraoral buccal sulcus approach. Bony pathology excised, followed by shaving and contouring of the expanded bone. (i-k) Bony defect packed with a mixture of fresh autologous platelet-rich fibrin and hydroxyapatite and tricalcium phosphate bone graft substitute granules. (l) Layer-wise closure

Figure 11: (Case 3) (a-d) Good postoperative healing with an excellent restoration of facial symmetry and esthetics. (e and f) Postoperative radiographs confirmed achievement of a symmetrical contour of the mid-third of the facial skeleton

of history, clinical and radiographic presentation, laboratory findings, and histological features.

FD of the craniofacial complex, may present in three forms, namely, polyostotic FD in which in addition to the craniomaxillofacial region other bones of the skeleton are involved as well; monostotic FD which involves a single skull bone (which could be either of the jaws or a cranial bone) or craniofacial FD which can contiguously involve multiple bones of the cranial base, vault and maxillofacial region to varying extents. Depending on the maturity of the lesion and the relative quantum of its "fibrous" and "osseous" components, FD can present a widely varying histopathological picture.[6]

The mere presence of FD of the craniofacial region is not in itself an indication for treatment. It is usually a slow-growing lesion that appears in childhood or adolescence, with a median onset at 9.5 years of age.[30]

Patients most often present with an asymptomatic swelling of the affected bone. Many small solitary lesions remain static and asymptomatic for long periods. In most cases, the growth of the lesion slows down and finally ceases in late teenage years or the early twenties and remains static thereafter. A marked or progressive facial deformity, pain or functional disabilities, particularly

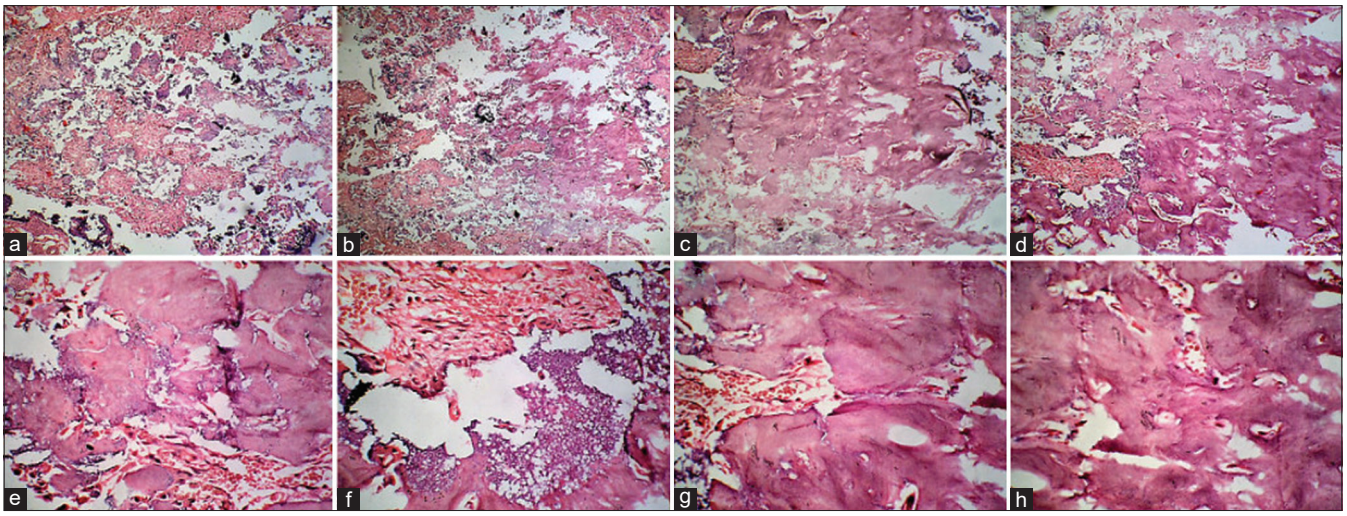

Figure 12: (Case 3) (a-d) Hematoxylin and eosin sections at ×10, showing numerous broad, irregularly shaped trabeculae of immature woven bone in a scanty fibrocellular connective tissue stroma. (e-h) Hematoxylin and eosin sections at ×100 showing the haphazardly oriented trabeculae which contained a few basophilic reversal lines, plump osteoblasts, and osteocytes. The computed tomography stoma contained a moderate number of fusiform, spindle-shaped fibroblasts and scattered hemosiderin deposits

airway of vision compromise, suggest the need for surgical intervention.[31]

Much controversy exists over the best surgical approach (e.g., early vs. late intervention, minimal vs. radical resection with primary or secondary reconstruction).[32] As the region affected is often large and involves complex facial anatomy, complete resection is usually not possible. Likewise, reconstruction can be challenging.

The surgical treatment of FD usually consists of conservative shaving/contouring.[33] Ideally, surgical intervention is recommended to be delayed until after skeletal maturity has been reached.[34] However, if the progression of the disease compromises neurological function or vision or threatens the airway,[35] a decompressive procedure should be considered early in childhood to preserve normal function. *En bloc* resection is reserved for patients with aggressive lesions that exhibit rapid or extensive growth, cause airway obstruction, or have recurred.[36]

In this case series, the patients were adolescents and adults of ages ranging from 15 to 72 years. Eight of them presented with the monostotic variant and seven with the craniofacial variant of FD. None of them exhibited features of polyostotic involvement of other bones of the skeleton or features of the McCune-Albright syndrome. Laboratory findings were insignificant except in two cases in which the serum alkaline phosphatase level was raised. The chief complaint in all of them was impaired esthetics due to the facial deformity and asymmetry caused by the bony enlargement, and local pain in the region in three patients. Surgical excision and contour shaving were carried out in all cases, with excellent esthetic and functional outcomes. There were nil early/late postoperative complications encountered and no incidence of recurrence or progression of the pathology, during the entire 2–3 years' follow-up.[19] All the patients in this study had reached skeletal maturity at the time of presentation, and surgical management was able to be undertaken immediately, with satisfactory outcomes in all cases.

Depending on the bone/bones of the craniomaxillofacial skeleton involved by FD, and the extent of involvement, various surgical approaches were employed in these patients to gain the access required for the exposure of the bone pathology as well as for surgical excision and shaving of the lesion, followed by recontouring. They included extraoral facial approaches such as a modified Blair incision with a temporal and endaural extension; a bicoronal incision; supraorbital/eyebrow incision with a crow's foot extension, and an Al Quayat and Bramley's modified preauricular incision; in addition to the standard intraoral vestibular and buccal sulcular approaches.

In two cases, there ensued a large residual defect following the excision of pathologic bone. In one of them, fresh autologous fat was harvested from the patient's abdominal wall and used to fill the large defect in the temporozygomatic region after removal of the pathologic bone. In the other patient, a large residual defect in the zygomatic buttress region was filled with PRF admixed with hydroxyapatite bone graft material to eliminate the dead space.

All the 15 cases of FD presented in this series, exhibited widely varying histological features. Some exhibited a densely collagenous and richly cellular fibrous CT stroma surrounding delicate, branching curvilinear trabeculae of immature woven bone, arranged in a pattern resembling "Chinese characters." In other patients, the histological picture comprised of a low to moderately cellular fibrous

Figure 13: (Case 4) (a-c) Facial asymmetry caused by bony expansion of the right supraorbital ridge and orbital roof. (d-l) Exposure through a supraorbital, lateral eyebrow approach with a crow's foot extension. Excision of the bony bulge over orbital roof, supraorbital ridge, and frontal bone. (m-t) Hematoxylin and eosin, showing the replacement of normal bone architecture by fibro-osseous tissue, comprising of irregular, broad trabeculae of mature lamellar bone containing numerous plump osteoblasts and a few basophilic reversal lines, interspersed by islands of densely cellular fibrous connective tissue

stroma containing irregular, broad trabeculae of woven bone which had numerous large osteoblasts and osteocytes. There was a conspicuous absence of osteoblastic rimming. Deeply basophilic reversal lines were present in some trabeculae mimicking Paget's disease. Still other cases demonstrated a histological picture of lamellar rather than woven bone, arranged in a haphazard fashion in a moderately cellular fibrous CT stroma. Secondary changes, such as cystic degeneration, a metaplastic chondroid component, and myxoid changes, were seen too. These findings made the diagnosis even more challenging. Careful correlation with the history elicited, clinical and radiographic features, and with laboratory investigations carried out, helped reach a definitive diagnosis in each case.

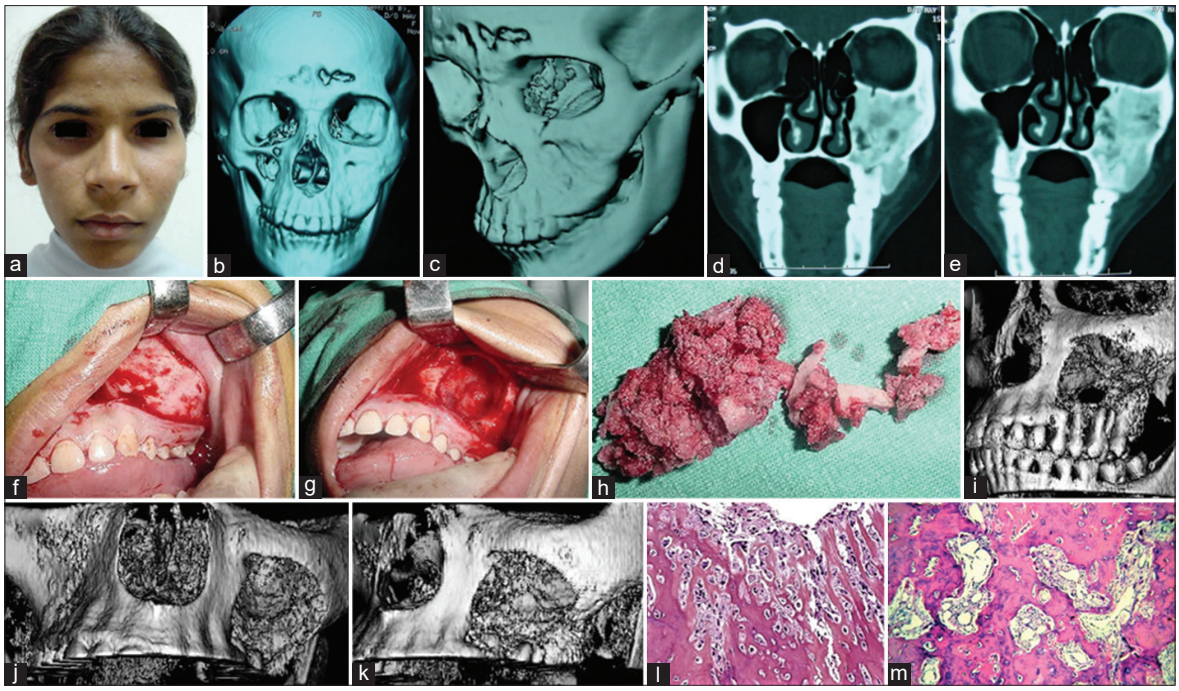

Figure 14: (Case 5) (a) Painless bony enlargement of the left maxillary region, obliterating the nasolabial fold. (b-e) Noncontrast computed tomography showing diffuse bony enlargement of the left maxilla, with a "ground glass" opacification, obliterating the maxillary antrum. (f-h) Intraoral vestibular approach to expose the expanded maxilla. Excision of soft, gritty pathological bony tissue, followed by extirpation of antral lining, curettage, and contouring. (i-k) Postoperative noncontrast computed tomography. (l and m) Hematoxylin and eosin sections, showing moderately dense fibrovascular computed tomography matrix containing numerous irregular trabeculae of immature woven bone

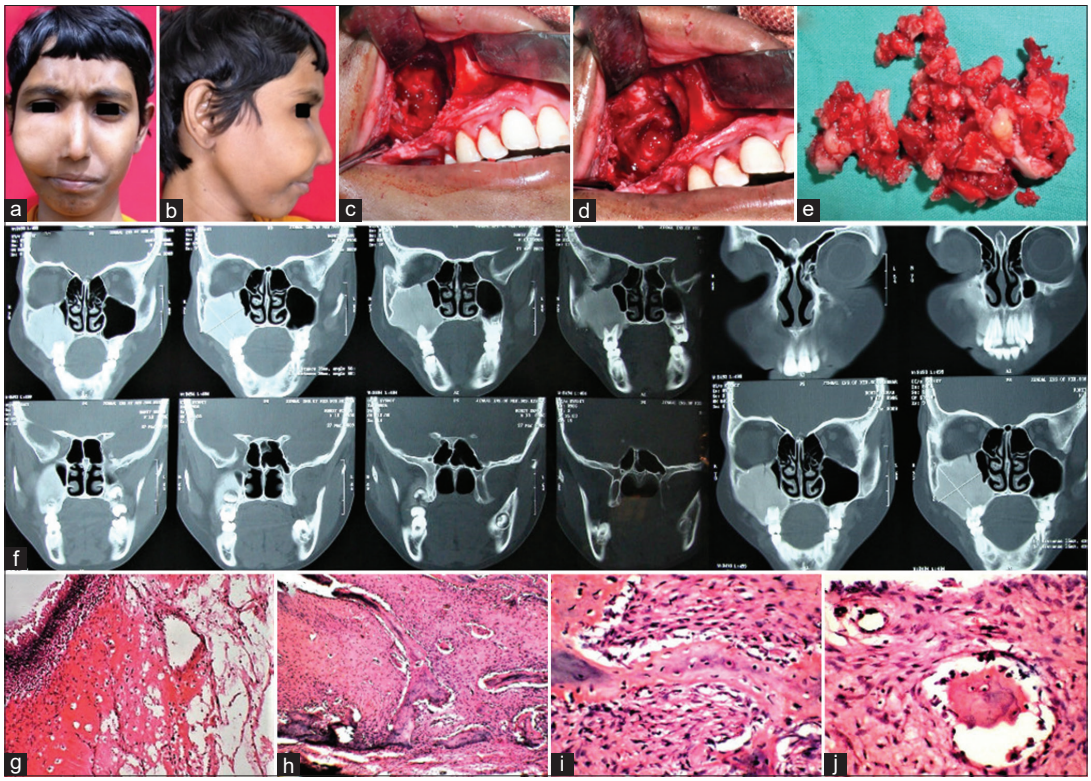

Figure 15: (Case 6) (a and b) Diffuse expansion of the right maxilla, with obliteration of nasolabial and nasofacial sulcus. (c-e) The exposure of lesion through intraoral vestibular approach, surgical excision, and curettage carried out, followed by bony recontouring. (f) Preoperative noncontrast computed tomography showing diffuse enlargement of the right maxilla with ground glass opacification obliterating the maxillary antrum. (g-j) Hematoxylin and eosin sections at ×100, showing a dense fibrocellular computed tomography matrix containing numerous irregular, branching, Chinese letter-shaped, and spherule-shaped trabeculae of immature woven bone

Figure 16: (Case 7) (a-f) Facial asymmetry and deformity caused by enlargement of the left ZMC complex. (g-k) Cone-beam computed tomography showing a diffuse and poorly defined mixed density bony lesion measuring approx. 3.6 cm × 3.3 cm × 3.8 cm in anteroposterior, transverse, and supero-inferior dimensions, in the region of the left maxilla, with diffuse trabecular effacement and islands of mildly sclerotic trabeculae, obliterating the left maxillary sinus. The lesion had a ground glass texture with indistinct, fuzzy transition zones, suggestive of a benign, nonodontogenic mixed density lesion, most likely, fibrous dysplasia

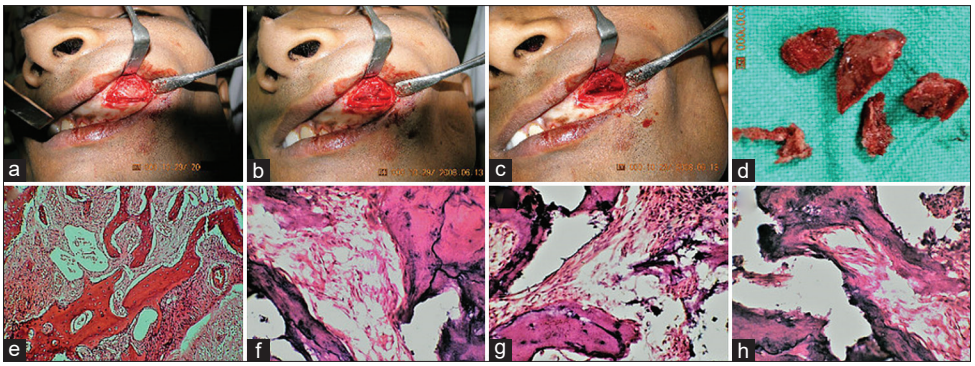

Figure 17: (Case 7) (a-d) Surgical excision followed by contour shaving and smoothening carried out through an intraoral upper vestibular approach. The excised specimen had a gritty consistency, softer than normal bone. (e-h) Hematoxylin and eosin sections at ×100 and ×200, showing haphazardly oriented broad, immature bony trabeculae, which contained a few basophilic reversal lines, plump osteoblasts, and osteocytes. The computed tomography stoma contained a moderate number of fusiform, spindle-shaped fibroblasts

Conclusion

Owing to the diverse clinical and radiographic presentations and varied microscopic appearances of FD, which can simulate or be imitated by a number of other FOLs, histopathological examination of a biopsy specimen alone is inadequate to make a definitive diagnosis. Correlation of HPE with history, clinical features, biological behaviour, radiographic and CT appearance, laboratory findings, and intraoperative findings is imperative, so that they can be distinguished from other bony lesions and an appropriate, ideal and effective treatment modality can be instituted in time, so as to achieve the most favorable esthetic and functional outcome.

Various surgical approaches may be employed to access the lesions, depending on their location, extent, and involvement. Treatment protocols range from complete surgical excision to surgical shaving and recontouring and must be decided on a case to case basis, with the aim to achieve the best possible esthetic and functional outcome with the least postoperative morbidity.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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