

## Original Article

# Benign fibro-osseous lesions of the jaws: a clinicopathologic study of 98 Tanzanian patients

Ntokozi C. Dube<sup>1</sup>, Jeremiah Robert Moshy<sup>2</sup>, Edda A. Vuhahula<sup>3</sup>, Karpal Singh Sohal<sup>2,\*</sup>

<sup>1</sup> Department of Oral and Maxillofacial Surgery, Mbabane Government Hospital, Mbabane, Swaziland

<sup>2</sup> Department of Oral and Maxillofacial Surgery, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

<sup>3</sup> Department of Pathology, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania

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**Abstract – Introduction:** The benign fibro-osseous lesions (BFOL) are characterized by replacement of the normal bone by cellular fibrous tissue containing various forms of ossification. They encompass common clinical, radiologic and histopathological features and hence pose considerable diagnostic and therapeutic challenges to clinicians and pathologists. **Objective:** To analyze the clinico-pathological and radiological features of BFOLs of the jaws in patients treated at Muhimbili National Hospital, Tanzania. **Material and methods:** A retrospective study of files of patients who were diagnosed with BFOLs from January 2011 to December 2013 was done. The collected information included data on demographic characteristics, the duration of the lesion, location of the lesion, presence of swelling, associated symptoms and reported radiological and histological features. **Results:** A total of 98 patient's records were retrieved. There was a predominance of females (59, 60.2%), with a male to female ratio of 1:1.5. The patient's age at presentation ranged from 5 years to 75 years with a mean age of  $29.81 \pm 15.28$  years. Four types of BFOLs were encountered. Ossifying fibroma were the most frequent (61.2%), followed by fibrous dysplasia (19.4%). Maxilla was more affected than the mandible. Majority (>70%) of the BFOLs were radio-opaque. The common histological features in all four types of BFOL included presence of: woven bone in fibrous stroma, giant cells, loose collagen and foci of hemorrhage. **Conclusion:** In this sample, BFOLs, were slightly more prevalent in females than males, affecting individuals below 40 years at large. They showed several overlapping clinical, radiological and histological features; thus a combination of different modalities seems necessary for an accurate diagnosis.

## Introduction

The benign fibro-osseous lesions (BFOL) are a poorly defined group of lesions that share the same evolutive mechanism [1,2]. They are characterized by replacement of the normal bone by an often cellular fibrous tissue containing various forms of ossification [1,2]. This group of lesions is known to encompass common characteristics that include common clinical, radiologic and histopathological features; hence they pose considerable diagnostic and therapeutic challenges to clinicians and pathologists [3].

Despite having similar features, each type of BFOLs have a different treatment modality. Ossifying fibroma (OF) require complete enucleated from surrounding bone since it has a high risk of recurrence. Whereas, fibrous dysplasia (FD) is managed conservatively because of its self-limiting nature [4]. The

central giant cell granuloma (CGCG) have been managed traditionally by local curettage [5]. Therefore, considering the different management for each type of BFOL, a need for accurate diagnosis is of paramount importance for the proper management of these lesions.

There are several subtypes of BFOL which includes osseous dysplasia (OD), OF and FD [2,3,6,7]. Findings from Nigeria [3,6] indicate that ossifying fibroma is the most prevalent BFOL, while a study from Uganda [7] reported that FD is the most common lesion followed by ossifying fibroma. To the contrary, OD is reported to be the commonest BFOLs in studies from Brazil [2] and China [1]. Typical OD is common in middle-aged black women [8].

The frequency and specific characteristics of BFOLs in Tanzania have not been extensively studied so far. This study was designed with the aim of analyzing the clinico-pathological and radiological features of benign fibro-osseous lesions of the jaws in patients treated in the department of oral and maxillofacial surgery at Muhimbili National Hospital, Tanzania.

\* Correspondence: [karpal@live.com](mailto:karpal@live.com)

## Materials and methods

This was a retrospective descriptive cross-sectional hospital-based study that took place at the Oral and Maxillofacial Unit of the Muhimbili National Hospital (MNH) in 2014. The permission to conduct this study was granted by the Research and Ethical Committee of the Muhimbili University of Health and Allied Sciences (MUHAS).

Hospital files of patients who were diagnosed with benign fibro-osseous lesions (BFOLs) at the oral and maxillofacial unit of MNH between 2011 and 2013 were included in the study. The collected information included data on demographic characteristics, the duration of the lesion, location of the lesion, presence of swelling, associated symptoms and reported radiological features. Confidentiality was maintained and identification numbers instead of patients' names were used in the questionnaires and clinical forms.

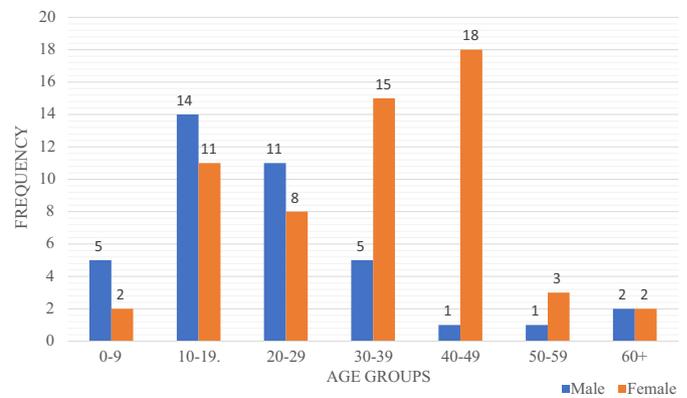
The hematoxylin and eosin (H&E) stained sections of tissue biopsies were reviewed under light microscopy by an oral pathologist to confirm the diagnosis of cases subjected to surgical procedures for both diagnostic and treatment purposes, and the histopathological findings were documented as well in the special laboratory form. In cases where there were two samples, of tissue (*i.e.* pre-operative and post-operative), then both were reviewed, but the final inclusion was the post-operative biopsy since the sample was larger and thus more representative. No tissue biopsy was taken in cases of OD. To ensure efficiency and consistency, a sample of H&E stained sections of tissue biopsy were reviewed independently by another experienced pathologist and Cohen's Kappa statistics was performed. There was an almost perfect agreement between the two examiners in reporting the diagnosis [ $K = 0.842$  (95% CI, 0.542–1.142),  $p < 0.001$ ].

The information gathered from the structured questionnaire, clinical and histopathological forms were entered into a computer, processed and analyzed by using Statistical Package for Social Science (SPSS) version 22.0 (IBM Corporation Chicago, IL, USA).

The patients' age at presentation was subtracted from the reported duration of the lesion to obtain the age at which the lesion was first noted. The obtained age was then grouped into a range of 10 years and was also used to calculate the mean age of occurrence of a particular lesion. The 2005 criteria of World Health Organization (WHO) histological classification of BFOLs [9] was used for grouping the lesions in this study. Means and standard deviation were used to summarize continuous variables. Cross-tabulations between types of BFOL and selected variables (age, sex and clinical features) were generated. Pearson's chi-square or Fisher's exact test, as the case may be, were computed and the significance level was set at  $p < 0.05$ .

## Results

In the present study included the records of 98 patients who were diagnosed with benign fibro-osseous lesions affecting the



**Fig. 1.** Distribution of patients with BFOL according to age group and sex.

maxillofacial region. There was a predominance of females (59, 60.2%), with a male to female ratio of 1:1.5. The patients' age at presentation ranged from 5 years to 75 years with a mean age of  $29.81 \pm 15.28$  years. Majority (83, 84.7%) were in their 2nd to 5th decades of life at time of presentation (Fig. 1).

Four types of benign fibro-osseous lesions were encountered in this study. OF were the most frequent (60, 61.2%), followed by FD (19, 19.4%) and OD (12, 12.2%). CGCG was least frequent to be diagnosed (7, 7.1%). Of the OD, the diagnosed subtypes included focal OD (9, 75%), periapical OD (2, 16.7%) and florid OD (1, 8.3%).

The mean age of occurrence for ossifying fibromas was  $26.19 \pm 14.41$  years, and the peak was observed in 2nd and 4th decades of life. In these lesions, a male to female ratio of 1:1.1 was observed, with occurrence in the maxilla being slightly more than in mandible (mandible: maxilla was 1:1.1). Majority of ossifying fibromas were not painful on presentation (Tab. I).

The FD had observed peak at 2nd decade of life, with mean age of  $23.52 \pm 13.35$  years. The male to female ratio of 1:1.4 was observed, and the maxilla was affected more than the mandible (mandible: maxilla was 1:2.2). Fibrous dysplasias were mostly not painful on presentation (Tab. I).

The osseous dysplasias were predominantly observed after the 5th decade of life, with mean age of  $48.67 \pm 10.79$  years. These lesions were exclusively observed in the mandibles of the female patients in this study. Majority of the OD were not painful on presentation (Tab. I).

Most (57.1%) of CGCG occurred in the 1st decade of life. The mean age was  $13.43 \pm 10.56$  years. Females were slightly more affected than males (male: female was 1: 1.3). The mandible was commonly affected, with mandible to maxilla ratio of 6:1. The CGCG were mostly painful (57.1%) (Tab. I).

With the exception of OD, all other types of BFOLs presented as hard swellings. Less than half (41.7%) of the patients with OD had a notable swelling on presentation, and the swellings were hard on palpation.

Table II presents the different radiological and histopathological features of BFOL. Histological features of OD have not been reported as they were not biopsied and were diagnosed based on clinical and radiological features.

**Table I.** Distribution of patients according to demographics, clinical features and types of BFOL.

Socio-demographic characteristic and clinical features	Classification of BFOL according to WHO 2005				<i>p</i> -value
	Ossifying fibroma <i>n</i> = 60	Fibrous dysplasia <i>n</i> = 19	Osseous dysplasia <i>n</i> = 12	central giant cell granuloma <i>n</i> = 7	
Age groups (according to when the lesion was initially noted)					
0–9	11.7%	10.5%	–	57.1%	
10–19	26.7%	42.1%	–	14.3%	
20–29	15%	15.8%	–	28.6%	
30–39	31.7%	15.8%	–	–	<0.001
40–49	8.3%	10.5%	16.7%	–	
50–59	3.3%	5.3%	–	–	
60+	3.3%	–	83.3%	–	
Mean age	26.19	23.53	48.67	13.43	0.004
Sex					
Male	46.7%	42.1%	–	42.9%	0.027
Female	53.3%	57.9%	100%	57.1%	
Location of lesion					
Maxilla	51.7%	68.4%	–	14.3%	0.001
Mandible	48.3%	31.6%	100%	85.7%	
Symptoms other than swelling					
No pain	76.7%	68.4%	83.3%	42.9%	
Pain	13.3%	21.1%	16.7%	42.9%	0.336
Paraesthesia	6.7%	10.5%	–	–	
Pain and paraesthesia	3.3%	–	–	14.2%	
Local swelling	100%	100%	41.7%	100%	–

With the exception of CGCG, which appeared mostly (57.1%) as radiolucent in radiographic images, majority (>70%) of the rest of benign fibro-osseous lesions were radio-opaque. The radiological margins of ossifying fibroma and central giant cell were in most cases well defined, whereas those of FD were exclusively ill-defined (Tab. II). For the lesions located in the mandible, only ossifying fibroma presented with bowing of inferior border of mandible in all cases and displacement of inferior mandibular canal in 33.3% of cases.

## Discussion

BFOL of the maxillofacial bones make up a diverse collection of disorders that include neoplastic and non-neoplastic and hereditary and non-hereditary conditions [9]. These lesions have been classified and renamed by different authors over time due to their varied features [9,10]. In this study, the criteria of World Health Organization (WHO) histological classification of fibro-osseous lesions (2005) was adopted. 4 sub-types of fibro-osseous lesions were

analyzed, contrarily to other studies [1,2] which analyzed 2 or 3 types of BFOL. This difference may be attributed to methodological variations in inclusion criteria based on the type of classification of BFOLs used since so far there has been no universally accepted classifications of fibro-osseous jaw lesions [11]. However, it is worth to investigate the role played by geographical or racial factors and differences in diagnosis through multicentric prospective studies with standardized diagnosis criteria [7]. The racial factor may have a significant role in occurrence of BFOL, especially OD since it has been noted typically in middle-aged black women [8].

The most frequently encountered BFOLs in this study were OF and FD. This finding corresponds to reports from Nigeria [3,6] but differs from findings of a study from Uganda [7], in which FD was the most common lesion followed by OF. To the contrary, ODs were reported to be the commonest BFOLs in studies from Brazil [2] and China [1]. Overall, in the present study, BFOLs were slightly more prevalent in females than males. These findings that are in agreement with various similar studies [6,7,12,13].

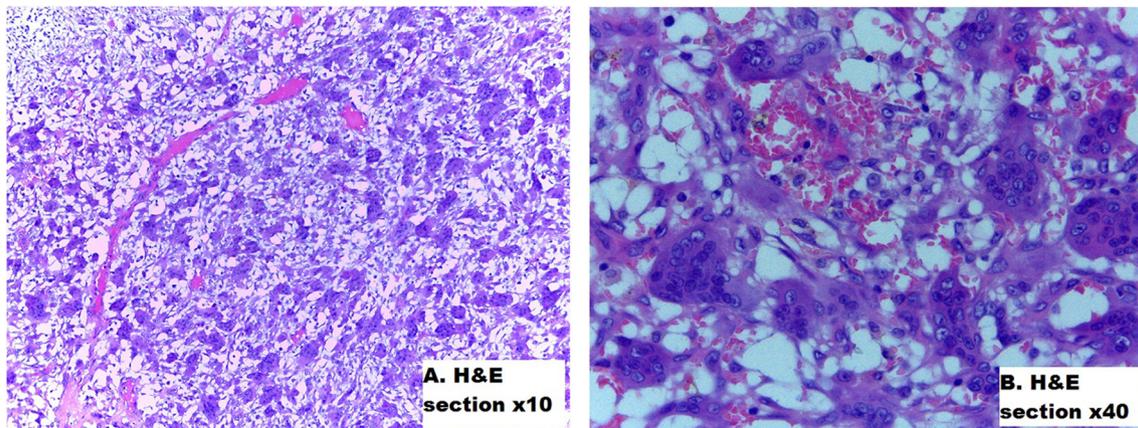
**Table II.** Radiological and histological characteristics of different types of BFOL.

Radiological and histopathological features	Classification of BFOL according to WHO 2005			
	Ossifying fibroma <i>n</i> = 60	Fibrous dysplasia <i>n</i> = 19	Osseous dysplasia <i>n</i> = 12	central giant cell granuloma <i>n</i> = 7
<b>Features of the image</b>				
Radiolucent	21.7%	–	–	57.1%
Mixed-density	6.7%	15.8%	8.3%	14.3%
Radio-opaque	71.6%	84.2%	91.7%	28.6%
Root resorption	33.3%	–	–	–
Root divergence	16.7%	–	–	100%
Displacement of teeth	41.7%	–	–	100%
<b>Borders of the image</b>				
Well defined	66.7%	–	41.7%	57.1%
Ill defined	33.3%	100%	58.3%	42.9%
<b>Histopathological features</b>				
Thick curvilinear trabeculae	98%	–	–	–
Separate bony trabeculae	100%	84.2%	–	–
Woven bone in fibrous stroma	100%	100%	–	100%
Variable amount of lamella bone	100%	33.3%	–	–
Storiform pattern	48.3%	5.3%	–	–
Giant cells	100%	100%	–	100%
Loose collagen	100%	100%	–	85.7%
Dense collagen	–	–	–	14.3%
Osteoblastic rimming	66.7%	–	–	–
Bone trabeculae with large osteocytes within lacunae	100%	31.6%	–	–
Haemorrhage foci	100%	100%	–	100%

**Fig. 2.** Radiological appearance of osseous dysplasia, as a well-defined multiple radiopaque mass with circumferential radiolucency, surrounding the root apices and scattered on both sides of the mandible.**Fig. 3.** An orthopantomograph showing an expansile, multilocular radiolucent lesion of a central giant cell granuloma extending from the left condylar region to the left parasymphysis region of the mandible causing displacement of teeth.

OD is a condition that has been interpreted as a dysplastic lesion or developmental anomaly confined to the tooth-bearing areas of the jaws or to edentulous alveolar processes [14,15]. OD are reported to be predominantly in black females, with a

peak incidence in the fourth and fifth decades [16]. Similar findings were obtained in this study. The pathogenesis of the ODs is unknown, although they appear to represent some form of reactive or dysplastic process [17]. Hormonal changes have



**Fig. 4.** H&E section of a central giant cell granuloma  $\times 10$  (A) and  $\times 40$  (B) showing multinucleated giant cells in scanty stroma with capillary proliferation.

been suggested as a probable cause or contributing factor to the condition [18]. In the current study, majority of the OD were asymptomatic and this was further augmented by the findings that most were incidental findings when patients came for other dental-related conditions. Radiologically, in this study, majority of the ODs were radio-opaque masses located in the mandible and less than a half had well defined radiological margins (Fig. 2). These findings differed with what was reported by Alsufiyani and Law [15]. However, they were in agreement with their findings that these lesions mostly do not cause root resorption nor displacement of teeth. The difference in the findings may be attributed to the large number of patients they reported upon compared to the ones in this study. Histopathologically, OD lesions are composed of anastomosing bone trabeculae and layers of cementum-like calcifications embedded in a fibroblastic background [14]. However, in the current study histopathological analysis of the OD was not done.

The CGCG is a benign bone lesion accounting for less than 7% of all benign tumors of the jaws [19]. In this study the lesions were exclusively observed in patients below 30 years of age, with a slightly female predominance. The lesions were mostly hard and affected the mandible more than the maxilla. These results concurred to what has been reported elsewhere [5,20,21]. The current study found that slightly more than half of the CGCG presented with symptomatic swelling, and pain being the most commonly associated symptom. Contrarily to the findings of this study, Amirchangmaghi *et al.* [5] reported that these lesions are usually asymptomatic. The findings of the current study depicted that radiologically, CGCG were mostly radiolucent lesions with well-demarcated borders that almost exclusively caused displacement of teeth and divergence of the roots of teeth (Fig. 3). These results were similar to those reported by Noleto *et al.* [22]. Diagnosis of CGCG is normally made histologically. It has been documented that histologically, the appearance is generally distinctive with cellular fibrous tissue containing



**Fig. 5.** An orthopantomograph showing an ossifying fibroma in the mandible appearing as a well-defined mixed radiopaque-radiolucent lesion causing bowing of the inferior border of the left side of the mandible.

multiple foci of hemorrhage, aggregations of multinucleated giant cells, and, occasionally, trabeculae of woven bone [20,23]. Similar histological findings were noted in this study (Fig. 4 A,B).

OF and FD are the most common benign fibro-osseous lesions in the maxillofacial region [4,24]. These two lesions can affect the maxillofacial bones and are characterized by bone replacement with cellular fibrous tissue containing foci of mineralization that vary in amount and appearance [25]. Typical cases of OF and FD are distinguished by radiological and histological appearances, yet still, these lesions often present a diagnostic dilemma due to similarities in some radiological and histological features [24].

Some of the differences noted between OF and FD in this study included the commonly affected age groups (OF in 4th decade vs FD in 2nd decade). Radiologically, majority of OF (Fig. 5) presented with well-defined borders, unlike FD which had ill-defined radiological borders (Fig. 6). Histopathological differences between OF (Fig. 7 A,B) and FD (Fig. 8 A,B) were noted in the presence of thick curvilinear trabeculae, storiform pattern and osteoblastic rimming in OF.



**Fig. 6.** An orthopantomography showing a fibrous dysplasia ill-defined, expansile, mixed radiopaque-radiolucent lesion with a ground-glass appearance, extending from the right coronoid process to the right parasymphysis region of the mandible.

The results of this study also found several overlapping clinical, radiological and histological features between OF and FD. These similar features make it difficult to arrive at a definitive diagnosis by using only a single diagnostic modality

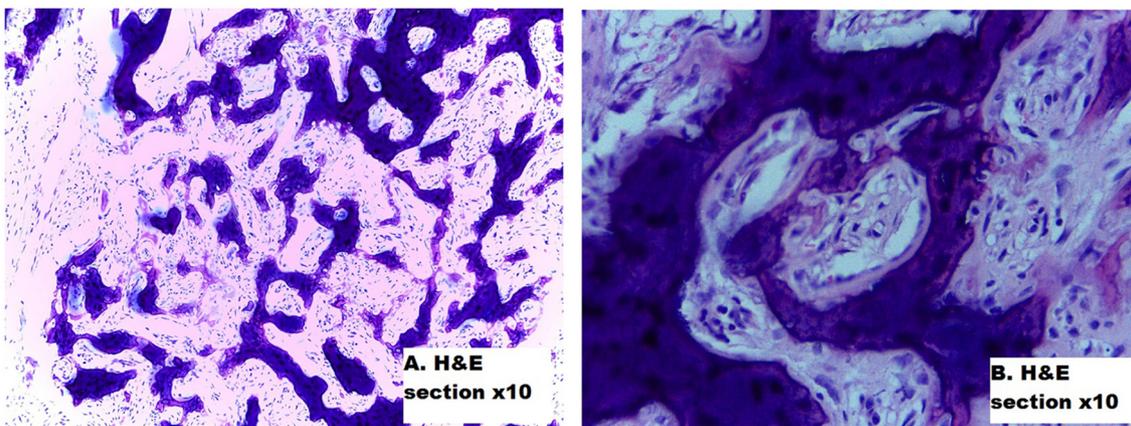
[4]. Accurate diagnosis of OF and FD is of utmost importance because, despite their histological similarities, these lesions differ dramatically in their biological behaviors and, thus, are managed by different approaches [26].

Some authors [26,27] have gone to the molecular level to differentiate FD from OF by studying mutation in GNAS gene, and their findings indicate that mutational analysis of GNAS gene is a reliable adjunct to differentiate OF and FD of the jaws, with the mutation being evident in FD.

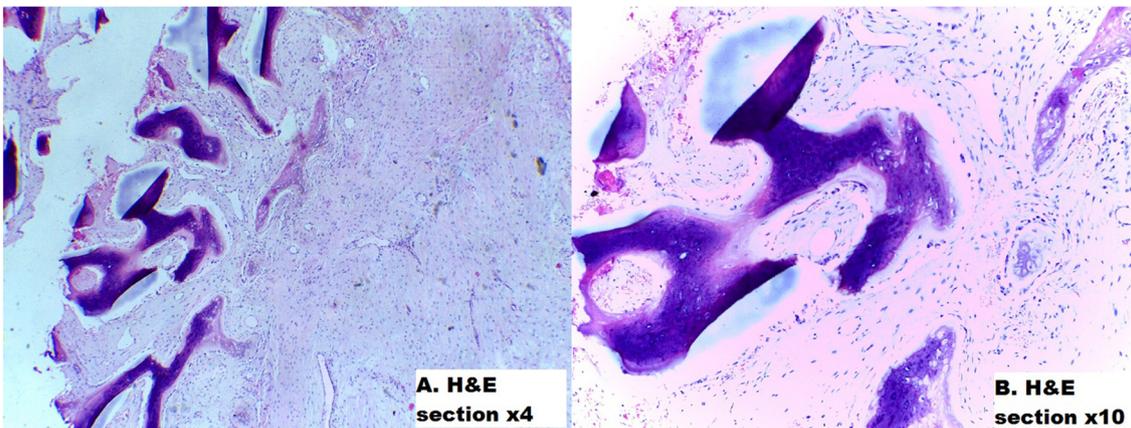
This study had an inherent limitation in that, being a hospital-based retrospective study, some information from clinical and radiological findings could not be extracted from the files of the patients, yet still, it highlights different clinical, radiological and histological features that may help clinicians and pathologists in coming up with a diagnosis.

### Conclusion

The results of this study highlighted the clinical, radiological and histopathological characteristics of various



**Fig. 7.** H&E section of an ossifying fibroma  $\times 10$  (A) and  $\times 40$  (B) showing a cellular fibroblastic stroma with interconnected bone trabeculae and osteoblastic rimming.



**Fig. 8.** H&E section of a fibrous dysplasia  $\times 4$  (A) and  $\times 10$  (B) showing fibrous component with curvilinear bone trabeculae (Chinese letter pattern).

benign fibro-osseous lesion among patients attended in the Muhimbili National Hospital. BFOLs, were slightly more prevalent in females than males, affecting individuals below 40 years at large. They presented with a hard swelling, and occasionally pain was the common associated symptom. Four distinct types of BFOLs were obtained, with OF and FD being more common. BFOLs presented with several overlapping clinical, radiological and histological features, thus a combination of different modalities seems necessary for an accurate diagnosis.

**Conflicts of interests:** The authors declare that they have no conflicts of interest in relation to this article.

## References

- Alsharif MJ, Sun Z, Chen X, Wang S, Zhao Y. Benign fibro-osseous lesions of the jaws: a study of 127 Chinese patients and review of the literature. *Int J Surg Pathol* 2009;17:122–134.
- Netto JD, Cerri JM, Miranda AM, Pires FR. Benign fibro-osseous lesions: clinicopathologic features from 143 cases diagnosed in an oral diagnosis setting. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2013;115:e56–e65.
- Sule AA, Iyogun CA, Adeyemi TE. Pattern of fibro-osseous lesions of the jaws in Kano, Northern Nigeria. *J Dent Oral Heal* 2017; 3:74.
- Moshy J, Dimba E, Ocholla T, Chindia M. Characteristic radiological and histological patterns of fibrous dysplasia and ossifying fibroma of the jaws at University of Nairobi Dental Teaching Hospital. *Surg Sci* 2012;3:189–193.
- Amirchamaghi M, Falaki F, Mohtasham N, Imanimoghaddam M. Central giant cell granuloma of the jaws. A clinical and radiographic study in Korasan (Iran). *J Appl Sci* 2010;10: 777–780.
- Iyogun CA, Dirisu N, Omitola OG, Sule AA. Pattern of fibro-osseous lesions of jaws in Port Harcourt in South-South Nigeria. *Ann Med Heal Sci Res* 2018;8:186–188.
- Muwazi LM, Kamulegeya A. The 5-year prevalence of maxillofacial fibro-osseous lesions in Uganda. *Oral Dis* 2015;21:79–81.
- Senia ES, Sarao MS. Periapical cemento-osseous dysplasia: a case report with twelve-year follow-up and review of literature. *Int Endod J* 2015;48:1086–1099.
- Srichinthu KK, Yoithappabhunath TR, Chitturi T, Yamunadevi A, Potsangbam AD, Singh DN. Fibro osseous lesions – classifications, pathophysiology and importance of radiology: a short review. *Int Biol Biomed J* 2016;2:11–20.
- Shilu K, Raviya P. Classifications of fibroosseous lesion with brief review on fibrous dysplasia. *Int J Adv Res Dev* 2018;3: 53–57.
- Worawongvasu R, Songkamol K. Fibro-osseous lesions of the jaws: an analysis of 122 cases in. *J Oral Pathol Med*. 2010;39: 703–708.
- Lasisi TJ, Adisa AO, Olusanya AA. Fibro-osseous lesions of the jaws in Ibadan, Nigeria. *OHDM* 2014;13:41–44.
- Phattarataratip E, Pholjaroen C, Tiranon P. A clinicopathologic analysis of 207 cases of benign fibro-osseous lesions of the jaws. *Int J Surg Pathol* 2014;22:326–333.
- Gonçalves M, Pispico R, Alves F de A, Lugão CEB, Gonçalves A. Clinical, radiographic, biochemical and histological findings of florid cemento-osseous dysplasia and report of a case. *Braz Dent J* 2005;16:247–250.
- Alsufyani NA, Lam EWN. Osseous (cemento-osseous) dysplasia of the jaws: clinical and radiographic analysis. *J Can Dent Assoc* 2011;77:b70.
- Kadam R, Patel S, Pathak J, Swain N, Kumar S. Focal cemento-osseous dysplasia. *J Contemp Dent* 2013;3:112–115.
- Dagistan S, Goregen M, Çakur B, Miloglu Ö. Cemento-osseous dysplasias. *Rev Clin Pesq Odontol* 2007;3:43–49.
- Gümüşok M, Alkurt MT, Hamurcu K, Kilavuz DK, Baris E, Simsek B. Focal cemento-osseous dysplasia. *J Oral Maxillofac Radiol* 2014; 2:92–94.
- Kruse-Losler B, Diallo R, Gaertner C, Mischke K-L, Joos U, Kleinheinz J. Central giant cell granuloma of the jaws: a clinical, radiologic, and histopathologic study of 26 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;101:346–354.
- Motamedi MHK, Eshghyar N, Jafari SM, Lassemi E, Navi F, Abbas FM, *et al.* Peripheral and central giant cell granulomas of the jaws: a demographic study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007;103:39–43.
- de Lange J, van den Akker HP, van den Berg H. Central giant cell granuloma of the jaw: a review of the. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007;104:603–615.
- Noletto JW, Marchiori E, Sampaio RK, Irion KL, Collares FB. Radiological and epidemiological aspects of central giant cell granuloma. *Radiol Bras* 2007;40:167–171.
- Pogrel AM. The diagnosis and management of giant cell lesions of the jaws. *Ann Maxillofac Surg* 2012;2:102–106.
- Toyosawa S, Yuki M, Kishino M, Ogawa Y, Ueda T, Murakami S, *et al.* Ossifying fibroma vs fibrous dysplasia of the jaw: molecular and immunological characterization. *Mod Pathol* 2007;20:389–396.
- Mesquita Netto AC, Gomez RS, Diniz MG, Fonseca-Silva T, Campos K, De Marco LC, *et al.* Assessing the contribution of HRPT2 to the pathogenesis of jaw fibrous dysplasia, ossifying fibroma, and osteosarcoma. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2013;115:359–367.
- Patel MM, Wilkey JF, Abdelsayed R, D'Silva NJ, Malchoff C, Mallya SM. Analysis of GNAS mutations in cemento-ossifying fibromas and cemento-osseous dysplasias of the jaws. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;109:739–743.
- Shi R-R, Li X-F, Zhang R, Chen Y, Li T-J. GNAS mutational analysis in differentiating fibrous dysplasia and ossifying fibroma of the jaw. *Mod Pathol* 2013;26:1023–1031.