Int. J. Oral Maxillofac. Surg. 2019; xxx: xxx–xxx
https://doi.org/10.1016/j.ijom.2019.06.029, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Systematic Review
Clinical Pathology

Juvenile ossifying fibroma of the jaws and paranasal sinuses: a systematic review of the cases reported in the literature

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B. R. Chrcanovic, R. S. Gomez: Juvenile ossifying fibroma of the jaws and paranasal sinuses: a systematic review of the cases reported in the literature. Int. J. Oral Maxillofac. Surg. 2019; xxx: xxx–xxx.

Abstract. The aim was to compare clinical and radiological features of the two juvenile ossifying fibroma (JOF) variants, trabecular (JTOF) and juvenile psammomatoid ossifying fibroma (JPOF). An electronic search was undertaken in March 2019. Eligibility criteria included publications having sufficient clinical, radiological, and histological information to confirm the diagnosis. A total of 185 publications and 491 cases were included. Most JOFs, including both variants, showed bone expansion, were painless, presented no cortical perforation and no secondary aneurysmal bone cyst, did not cause tooth root resorption, and had a mixed unilocular radiodensity appearance and well-defined limits on radiological examination. Patients with JPOF were on average older than those with JTOF. Enucleation and curettage was associated with a considerably high recurrence rate, regardless of the anatomical location or variant type of the lesion. Enucleation followed by either curettage or peripheral osteotomy showed lower recurrence rates than enucleation only. When resection was performed, only one case of JTOF presented recurrence. In conclusion, JOF lesions presented high rates of recurrence after treatment by curettage and enucleation only. Although surgical resection of JOFs resulted in the virtual absence of recurrence, enucleation followed by peripheral osteotomy/curettage should be the treatment of choice for both JOF variants to avoid the disfigurement usually associated with surgical resection.

Key words: juvenile ossifying fibroma; trabecular type; psammomatoid type; jaws; paranasal sinuses; clinical features; recurrence rate.

Accepted for publication 26 June 2019

Ossifying fibromas are benign fibro-osseous neoplasms affecting the jaws and the craniofacial skeleton. They can be divided into the conventional form of ossifying fibroma, also called cemento-ossifying fibroma, and two distinct juvenile ossifying fibromas (JOF), namely juvenile trabecular ossifying fibroma (JTOF) and juvenile psammomatoid ossifying fibroma (JPOF), which are most commonly seen in the younger age group. JTOF usually occurs in the maxilla and JPOF

0901-5027/000001+010

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has a predilection for the paranasal sinuses. Histologically, JTOF shows loose fibroblastic tissue with areas of collagen condensation, with subsequent deposition of minerals leading to the formation of trabeculae of woven bone; JPOF shows cellular fibrous stroma and characteristic spheroidal calcifications called psammoma bodies[1,2].

Many case reports and case series of JTOF and JPOF have been published to date, but a more comprehensive review of the literature is important to delineate the main clinical/radiological features of the two conditions, which could help refine the criteria for the differential diagnosis of benign fibro-osseous lesions of the jaws and craniofacial skeleton. Hence, this review was performed to delineate the features of JTOF and JPOF and also to investigate possible features that may have an influence on the frequency of recurrence following the treatment of these lesions.

Materials and methods

This study followed the guidelines of the PRISMA Statement[3].

Search strategy

An electronic search without time restriction was undertaken in March 2019 in the PubMed/MEDLINE, Web of Science, ScienceDirect, J-STAGE, and LILACS databases. The following terms were used in the search strategies: ''juvenile ossifying fibroma'' OR ''periodontoma'' OR ''desmo-osteoblastoma'' OR ''psammomatoid ossifying fibroma'' OR ''psammomatoid type ossifying fibroma'' OR ''juvenile trabecular ossifying fibroma'' OR ''juvenile psammomatoid ossifying fibroma'' OR ''juvenile aggressive ossifying fibroma''.

Google Scholar was also checked. A manual search of all related oral pathology, maxillofacial, and specialist dental and oral journals was performed. The reference lists of the identified studies and relevant reviews on the subject were also checked for possible additional studies, as well as the cases listed in a book[4]. Publications with lesions identified by other authors as being JOF, even those without these terms in the title of the article, were also re-evaluated.

Inclusion and exclusion criteria

Publications reporting cases of JOF with sufficient clinical, radiological, and histological information to confirm the diagnosis were included.

Definitions

The histopathological definitions and criteria outlined below were used to diagnose a lesion as JTOF or JPOF.

JTOF is an unencapsulated tumour with a hypercellular stroma composed of spindle cells, with little collagen production and with long slender strands of osteoid. The immature bone trabeculae show no maturation and are usually devoid of osteoblastic rimming. The lesions are sharply demarcated from their surroundings, either by a fibrous capsule or by a rim of the pre-existing bone[1,2]. Tumours without strands of osteoid were excluded.

JPOF is an unencapsulated tumour containing multiple irregular and spherical psammomatoid basophilic bodies with a concentric pattern of lamination embedded in cellular fibroblastic stroma. The psammoma body-like ossicles are relatively acellular and show peripheral eosinophilic rimming[2]. As reported by Makek[4] (page 146, figure 175), there is no clear evidence of capsule in the periphery of the tumour, but rather the new bone formation appears to be simply reactive. Despite the cellularity, mitotic figures are not evident and there is minimal extracellular collagen deposition. Tumours without psammomatoid basophilic body formation were excluded.

As well as classification into these two histopathological groups, the cases were further classified into three groups according to the predominant region of anatomical involvement of the lesion: (1) maxilla (involving or not the maxillary sinus); (2) mandible; (3) paranasal sinuses (involving or not the nasal cavity and/or orbit). Cases with involvement of the skull bones (here exception is logically applied to the frontal bone, which contains the frontal sinus) or other regions of the body were not considered for the present review, except when the lesion extended from one of the three anatomical regions mentioned above.

Concerning the complementary surgical procedures, curettage after enucleation is performed by scraping the bone with curettes, while peripheral osteotomy

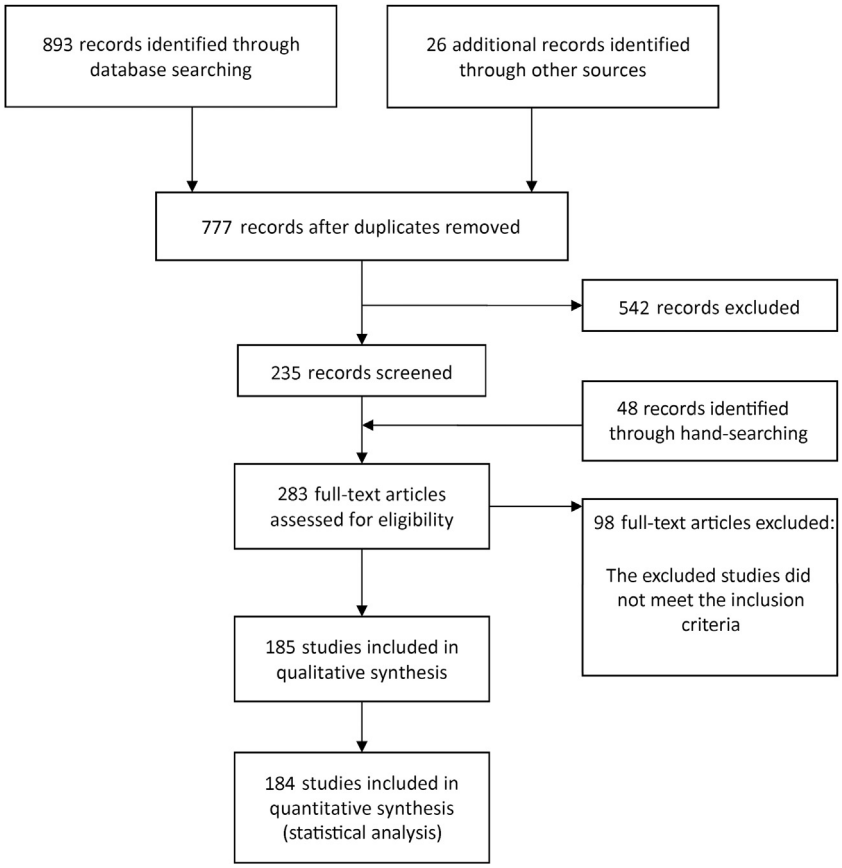

Fig. 1. Study screening process.

Table 1. Demographic and clinical features of juvenile ossifying fibroma described in the literature, according to the predominant anatomical location and subsequently to the histopathological type.

Variables	Maxilla/mandible[a,b]			Paranasal sinuses[a]			Global[a,b]		
	Trabecular	Psammomatoid	*P*-value[c]	Trabecular	Psammomatoid	*P*-value[d]	Trabecular	Psammomatoid	*P*-value[e]
Number	131	131		12	131		143	262	
Age (years), mean ± SD (min–max)	11.3 ± 6.1 (1–33) (*n* = 131)	18.8 ± 10.9 (4–59) (*n* = 131)	<0.001[f]	13.5 ± 5.4 (6–24) (*n* = 12)	18.9 ± 13.0 (0–68) (*n* = 129)	0.215[f]	11.5 ± 6.0 (1–33) (*n* = 143)	18.9 ± 12.0 (0–68) (*n* = 260)	<0.001[f]
Duration of symptoms before treatment (months), mean ± SD (min–max)	13.0 ± 17.9 (0–96) (*n* = 58)	41.6 ± 66.8 (0–360) (*n* = 55)	<0.001[f]	4.6 ± 6.4 (0.8–12) (*n* = 3)	30.6 ± 32.8 (0.5–144) (*n* = 66)	0.056[f]	12.6 ± 17.6 (0–96) (*n* = 61)	35.6 ± 51.2 (0–360) (*n* = 121)	<0.001[f]
Sex, *n* (%)									
Male	61 (46.9)	74 (56.5)	0.122[g]	8 (66.7)	76 (58.9)	0.421[h]	69 (48.6)	150 (57.7)	0.080[g]
Female	69 (53.1)	57 (43.5)		4 (33.3)	53 (41.1)		73 (51.4)	110 (42.3)	
Unknown	1	0		0	2		1	2	
Bone expansion, *n* (%)									
Yes	94 (100)	83 (100)	[i]	5 (100)	73 (81.1)	0.364[h]	99 (100)	156 (90.2)	0.001[g]
No	0 (0)	0 (0)		0 (0)	17 (18.9)		0 (0)	17 (9.8)	
Unknown	37	48		7	41		44	89	
Symptomatic, *n* (%)									
Yes	6 (8.6)	4 (5.0)	0.292[h]	0 (0)	3 (3.5)	0.901[h]	6 (8.2)	7 (4.2)	0.171[h]
No	64 (91.4)	76 (95.0)		3 (100)	83 (96.5)		67 (91.8)	159 (95.8)	
Unknown	61	51		9	45		70	96	
Cortical bone perforation, *n* (%)									
Yes	28 (36.8)	26 (38.8)	0.809[g]	0 (0)	19 (31.1)	0.241[h]	28 (35.0)	45 (35.2)	0.982[g]
No	48 (63.2)	41 (61.2)		4 (100)	42 (68.9)		52 (65.0)	83 (64.8)	
Unknown	55	64		8	70		63	134	
Locularity, *n* (%)									
Unilocular	52 (74.3)	46 (69.7)	0.551[g]	5 (100)	57 (80.3)	0.350[h]	57 (76.0)	103 (75.2)	0.895[g]
Multilocular	18 (25.7)	20 (30.3)		0 (0)	14 (19.7)		18 (24.0)	34 (24.8)	
Unknown	61	65		7	60		68	125	
Radiodensity, *n* (%)									
Radiolucent	16 (19.5)	12 (12.9)	0.244[g,j]	1 (16.7)	9 (10.2)	0.505[h,j]	17 (19.3)	21 (11.6)	0.091[g,j]
Radiopaque	1 (1.2)	2 (2.2)		0 (0)	1 (1.2)		1 (1.1)	3 (1.7)	
Mixed	65 (79.3)	79 (84.9)		5 (83.3)	78 (88.6)		70 (79.6)	157 (86.7)	
Unknown	49	38		6	43		55	81	
Radiological limits, *n* (%)									
Well-defined	76 (92.7)	82 (95.3)	0.344[h]	5 (83.3)	81 (97.6)	0.191[h]	81 (92.0)	163 (96.4)	0.111[h]
Ill-defined	6 (7.3)	4 (4.7)		1 (16.7)	2 (2.4)		7 (8.0)	6 (3.6)	
Unknown	49	45		6	48		55	93	
Secondary aneurysmal bone cyst, *n* (%)									
Yes	7 (9.3)	15 (20.3)	0.060[g]	0 (0)	6 (8.2)	0.718[h]	7 (8.9)	21 (14.3)	0.238[g]
No	68 (90.7)	59 (79.7)		4 (100)	67 (91.8)		72 (91.1)	126 (85.7)	
Unknown	56	57		8	58		64	115	
Tooth displacement, *n* (%)									
Yes	38 (57.6)	38 (56.7)	0.920[g]	–	–	–	38 (53.5)	38 (24.7)	[k]
No	28 (42.4)	29 (43.3)		–	–		33 (46.5)	116 (75.3)	
Unknown	65	64		–	–		72	108	
Tooth root resorption, *n* (%)									
Yes	5 (7.0)	4 (5.9)	0.527[h]	–	–	–	5 (6.6)	4 (2.6)	[k]

Table 1 (*Continued*)

Variables	Maxilla/mandible[a,b]			Paranasal sinuses[a]			Global[a,b]		
	Trabecular	Psammomatoid	*P*-value[c]	Trabecular	Psammomatoid	*P*-value[d]	Trabecular	Psammomatoid	*P*-value[e]
No	66 (93.0)	64 (94.1)		–	–		71 (93.4)	151 (97.4)	
Unknown	60	63		–	–		76	107	
First treatment, *n* (%)									
None	2 (2.4)	3 (2.9)	–	0 (0)	1 (0.9)	–	2 (2.3)	4 (1.9)	–
Debulking	0 (0)	1 (1.0)		0 (0)	4 (3.7)		0 (0)	5 (2.3)	
Cosmetic reduction	1 (1.2)	0 (0)		0 (0)	0 (0)		1 (1.2)	0 (0)	
Curettage	19 (22.9)	28 (27.2)		1 (25.0)	29 (26.6)		20 (23.0)	57 (26.9)	
Enucleation (global)	31 (37.4)	39 (37.9)		2 (50.0)	58 (53.2)		33 (37.9)	97 (45.8)	
Enucleation only	23 (27.7)	21 (20.4)		2 (50.0)	51 (46.8)		25 (28.7)	72 (34.0)	
Enucleation + curettage or peripheral osteotomy	8 (9.6)	18 (17.5)		0 (0)	7 (6.4)		8 (9.2)	25 (11.8)	
Marginal resection	11 (13.3)	7 (6.8)		1 (25.0)	14 (12.8)		12 (13.8)	21 (9.9)	
Segmental resection[l] (global)	19 (22.9)	25 (24.3)		0 (0)	3 (2.8)		19 (21.8)	28 (13.2)	
Segmental resection only	10 (12.0)	12 (11.6)		0 (0)	0 (0)		10 (11.5)	12 (5.7)	
Segmental resection + fixation	3 (3.6)	5 (4.8)		0 (0)	0 (0)		3 (3.4)	5 (2.3)	
Segmental resection + graft + fixation	6 (7.2)	8 (7.8)		0 (0)	3 (2.8)		6 (6.9)	11 (5.2)	
Unknown	48	28		8	22		56	50	
Recurrence, *n* (%)									
Yes	27 (31.8)	28 (32.9)	0.870[g]	4 (50.0)	25 (27.8)	0.178[h]	31 (33.3)	53 (30.3)	0.609[g]
No	58 (68.2)	57 (67.1)		4 (50.0)	65 (72.2)		62 (66.7)	122 (69.7)	
Unknown	46	46		4	41		50	87	
Time between treatment and first recurrence (months), mean ± SD (min–max)	15.4 ± 12.7 (3–42) (*n* = 23)	23.3 ± 20.7 (3–72) (*n* = 22)	0.071[f]	11 (*n* = 1)	32.3 ± 44.1 (3–192) (*n* = 23)	1.000[f]	15.2 ± 12.5 (3–42) (*n* = 24)	27.9 ± 34.6 (3–192) (*n* = 45)	0.091[f]
Follow-up time (months), mean ± SD (min–max)	57.5 ± 77.8 (2–384) (*n* = 79)	46.4 ± 53.3 (2–240) (*n* = 78)	0.329[f]	11.7 ± 0.6 (11–12) (*n* = 3)	37.8 ± 53.4 (1–300) (*n* = 68)	0.273[f]	55.9 ± 76.8 (3–384) (*n* = 82)	42.4 ± 53.3 (1–300) (*n* = 146)	0.079[f]
Lesion size (cm), mean ± SD (min–max)	5.3 ± 3.2 (1–17) (*n* = 65)	5.8 ± 3.2 (2.5–20) (*n* = 70)	0.168[f]	4.0 ± 1.9 (1.9–5,5) (*n* = 3)	4.8 ± 2.1 (1–15) (*n* = 60)	0.703[f]	5.3 ± 3.1 (1–17) (*n* = 68)	5.3 ± 2.8 (1–20) (*n* = 130)	0.483[f]

SD, standard deviation.

[a] Johnson et al. (1991)[5] did not provide detailed information on the histopathological subtypes of juvenile ossifying fibroma for their cases; thus, these cases are not included in these analyses.

[b] One trabecular case reported by Slootweg et al. (1994)[6] was not included in the analyses as it was multicentric, with lesions in the maxilla and the mandible.

[c] Comparison between trabecular and psammomatoid lesions located in the maxilla/mandible.

[d] Comparison between trabecular and psammomatoid lesions located in the paranasal sinuses.

[e] Comparison between trabecular and psammomatoid lesions, all lesions considered.

[f] Mann–Whitney test.

[g] Pearson χ^2 test.

[h] Fisher's exact test.

[i] At least one variable in each two-way table upon which measures of association were computed was a constant, i.e. swelling was a constant.

[j] Comparison between 'radiolucent' and 'mixed'.

[k] The significance was not calculated here, as the majority of the psammomatoid lesions were not located in the jaws, and therefore 'tooth displacement' and 'tooth root resorption' could not be considered for all cases.

[l] Resection with continuity defect.

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after enucleation is performed by scraping the bone with drills.

Study selection

The titles and abstracts of all reports identified through the electronic searches were read independently by the authors. For studies appearing to meet the inclusion criteria, or for which data in the title and abstract were insufficient to make a clear decision, the full report was obtained. Disagreements were resolved by discussion between the authors. The clinical and radiological aspects, as well as the histological description of the lesions reported in the publications, were thoroughly assessed by one of the review authors (R.S.G.), an expert in oral pathology, in order to confirm the diagnosis of JTOF or JPOF. Despite the need for radiographic and clinical information, the main criterion for selecting the samples was microscopic (see above in the 'Definitions' section).

Data extraction

The following data were then extracted: patient sex and age, duration of the lesion prior to treatment, predominant anatomical location of the lesion (maxilla, mandible, paranasal sinuses), lesion size (largest diameter), perforation of cortical bone, swelling (expansion of the osseous region adjacent to the tumour), presence of clinical symptoms, locularity appearance on radiological examination (unilocular/multilocular), radiodensity (radiolucent, radiopaque, mixed), radiological limits of the lesion (well-defined, ill-defined), tooth displacement and/or tooth root resorption due to lesion growth, histopathological type (trabecular, psammomatoid), presence of a secondary aneurysmal bone cyst, treatment performed, recurrence, time to recurrence, and follow-up period. Authors were contacted for possible missing data.

Statistical analysis

The mean, standard deviation (SD), and percentages were presented as descriptive statistics. The Kolmogorov–Smirnov test was used to evaluate the normality of the variable distribution, and the Levene test was used to evaluate homoscedasticity. The Student *t*-test or Mann–Whitney test was performed for the comparison of two independent groups, depending on the data normality. The Pearson χ^2 test or Fisher's exact test was used for categorical variables, depending on the expected count of events in a 2×2 contingency table. Correlations between certain variables were tested. The probability of recurrence was calculated for some variables. The association between recurrence and predictor variables of interest was expressed as the odds ratio (OR) with 95% confidence interval (95% CI) in a multivariate logistic regression model. The degree of statistical significance was considered $P < 0.05$. All data were statistically analyzed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA).

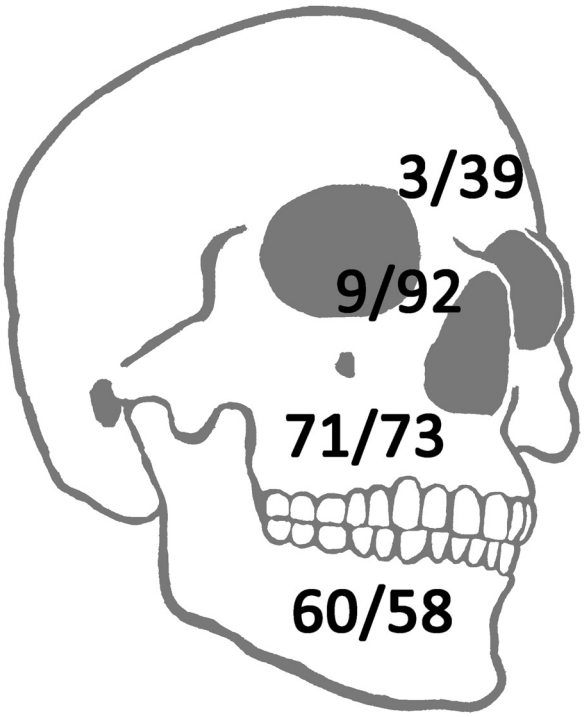

Fig. 2. Distribution of the 405 juvenile ossifying fibromas according to the predominant region of anatomical involvement of the lesion and the histopathological type. The figures represent the number of trabecular/psammomatoid lesions at each site. One trabecular case reported by Slootweg et al. (1994) is not included here as it was multicentric, with lesions in the maxilla and the mandible.

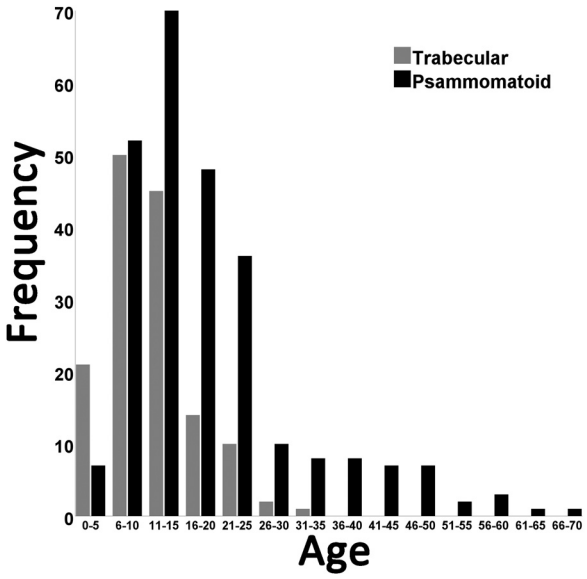

Fig. 3. Distribution of juvenile ossifying fibromas according to variant and age (for cases in which patient age was reported, $n = 403$).

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Results

Literature search

The study selection process is summarized in Fig. 1. The search strategy in the databases resulted in 893 papers; 26 additional eligible papers were found in Google Scholar and 48 papers through the handsearch. Finally, a total of 185 publications were included (see Supplementary Material Appendix for a full list of the 185 publications).

Description of the studies and analyses

This review identified 185 publications reporting 491 JOF cases. Unfortunately, there was no information on the JOF histopathological subtype for the 85 cases (28 in the maxilla/mandible, 57 in the paranasal sinuses) reported by Johnson et al.[5]. Moreover, one trabecular case reported by Slootweg et al.[6] was not included in the analyses as it was multicentric, with lesions in the maxilla and the mandible. Therefore, these 86 cases were not included in the analyses. Thus, an analysis of 405 cases is presented (Table 1).

JTOFs in the paranasal sinuses were the least found in the literature ($n = 12$), while JTOFs in the maxilla/mandible, JPOFs in the maxilla/mandible, and JPOFs in the paranasal sinuses totalled 131 lesions each. Sixty JTOF (42.0%, 60/143) and 58 JPOF (22.1%, 58/262) cases involved the mandible (Fig. 2).

When all locations were compared together, the mean age of the patients with JPOF (18.9 ± 12.0 years) was significantly higher than that of the patients with JTOF (11.5 ± 6.0 years); see Fig. 3 for the comparison of the age distribution between the two variants. The same pattern of age distribution was observed for lesions in the maxilla/mandible and paranasal sinuses (Table 1). However, the duration of the lesion prior to treatment was also significantly longer for JPOFs in comparison to JTOFs.

Most JOFs, including both variants, showed bone expansion, were painless, presented no cortical perforation and no secondary aneurysmal bone cyst, did not cause tooth root resorption, and had a mixed unilocular radiodensity appearance and well-defined limits on radiological examination. There was no significant difference between JTOFs and JPOFs with regard to the sex distribution, prevalence of bone expansion, pain, cortical bone perforation, locularity appearance on radiological examination, radiodensity, radiological limits, cortical bone perforation, presence of secondary aneurysmal bone cyst, tooth displacement, tooth root resorption, recurrence rate, time between treatment and first recurrence, follow-up time, or mean lesion size.

Eighty-four lesions recurred (20.7%, 84/405) (Table 1). There was precise information about the time to recurrence for 69 lesions, of which 56.5% recurred within 1 year after treatment and 75.4% within 2 years. The correlation between age and recurrence was very weak, both for JTOF ($r = 0.167$, $P = 0.111$, Spearman correlation) and for JPOF lesions ($r = 0.123$, $P = 0.105$, Spearman correlation). JPOFs took a longer mean time to recur in comparison to JTOFs, but with no statistical significance. The mean period of follow-up was longer for JTOFs than for JPOFs, but the difference was not statistically significant.

Enucleation and curettage had a considerably high recurrence rate, regardless of the anatomical location or the variant type of the lesion. Enucleation followed by either curettage or peripheral osteotomy showed lower recurrence rates than enucleation only. When resection was performed, only one case of JTOF in the paranasal sinuses presented recurrence (Table 2).

There was no significant difference in recurrence rate between curettage and enucleation, except in the case of JPOFs in the jaws (Tables 3 and 4). Treatment was the only factor suggested to exert some influence on the probability of JTOF recurrence, favouring surgical resection (either marginal or segmental) in relation to curettage or enucleation (Table 3). For JPOF, enucleation followed by ostectomy or curettage exerted some influence on recurrence compared to curettage or enucleation only (Table 4).

Table 2. Treatment recurrence (first treatment) for juvenile ossifying fibroma according to the predominant anatomical location and subsequently to the histopathological type—for lesions with available information about treatment and recurrence.

Treatment	Maxilla/mandible Recurrence/total (% recurrence)		Paranasal sinuses Recurrence/total (% recurrence)		Global Recurrence/total (% recurrence)		Total	*P*-value[a]
	Trabecular	Psammomatoid	Trabecular	Psammomatoid	Trabecular	Psammomatoid		
Debulking	–	1/1 (100)	–	3/3 (100)	–	4/4 (100)	4/4 (100)	
Cosmetic reduction	1/1 (100)	–	–	–	1/1 (100)	–	1/1 (100)	0.028[b] (C vs. E)
Curettage (C)	10/16 (62.5)	15/25 (60.0)	–	9/27 (33.3)	10/16 (62.5)	24/52 (46.2)	34/68 (50.0)	0.214[b] (C vs. EO)
Enucleation (global) (E)	12/26 (46.2)	11/33 (33.3)	0/2 (0)	13/47 (27.7)	12/28 (42.9)	24/80 (30.0)	36/108 (33.3)	0.002[b] (C vs. EP)
Enucleation only (EO)	10/20 (50.0)	8/16 (50.0)	0/2 (0)	13/40 (32.5)	10/22 (45.5)	21/56 (37.5)	31/78 (39.7)	0.023[b] (EO vs. EP)
Enucleation + curettage or peripheral osteotomy (EP)	2/6 (33.3)	3/17 (17.6)	–	0/7 (0)	2/6 (33.3)	3/24 (12.5)	5/30 (16.7)	<0.001[b] (EO vs. MR)
Marginal resection (MR)	0/9 (0)	0/7 (0)	1/1 (100)	0/11 (0)	1/10 (10)	0/18 (0)	1/28 (3.6)	0.113[c] (EP vs. MR)
Segmental resection[d] (SR)	0/18 (0)	0/14 (0)	–	0/2 (0)	0/18 (0)	0/16 (0)	0/34 (0)	0.019[c] (EP vs. SR)
Total	23/70 (32.9)	27/80 (33.8)	1/3 (33.3)	25/90 (27.8)	24/73 (32.9)	52/170 (30.6)	76/243 (31.3)	

[a] Comparison between treatments, but only when the total number of cases is considered.
[b] Pearson χ^2 test.
[c] Fisher's exact test.
[d] Resection with continuity defect.

Please cite this article in press as: Chrcanovic BR, Gomez RS. Juvenile ossifying fibroma of the jaws and paranasal sinuses: a systematic review of the cases reported in the literature, *Int J Oral Maxillofac Surg* (2019), https://doi.org/10.1016/j.ijom.2019.06.029

Table 3. Recurrence rate for trabecular juvenile ossifying fibroma, according to different factors—for the lesions with available information about both recurrence and the factors included here.

Factor	Recurrence/total (% recurrence)	*P*-value[a]	OR (95% CI)	*P*-value[b]
Treatment				
Curettage (C)	10/16 (62.5)	0.299[c]	0.500 (0.134–1.862)	0.301 (C vs. EO)
Enucleation only (EO)	10/22 (45.5)	0.229[d]	0.300 (0.042–2.165)	0.232 (C vs. EP)
Enucleation + curettage or peripheral osteotomy (EP)	2/6 (33.3)	0.011[d]	0.067 (0.007–0.665)	0.021 (C vs. MR)
Marginal resection (MR)	1/10 (10.0)	<0.001[d]	[e]	- (C vs. SR)
Segmental resection[f] (SR)	0/18 (0)	0.479[d]	0.600 (0.090–3.986)	0.597 (EO vs. EP)
		0.056[d]	0.133 (0.014–1.240)	0.077 (EO vs. MR)
		0.001[d]	[e]	- (EO vs. SR)
		0.304[d]	0.222 (0.015–3.221)	0.270 (EP vs. MR)
		0.054[d]	[e]	- (EP vs. SR)
		0.357[d]	[e]	- (MR vs. SR)
Anatomical location				
Maxilla/mandible	27/85 (31.8)	0.251[d]	1	
Paranasal sinuses	4/8 (50.0)		2.148 (0.499–9.242)	0.304
Bone expansion[g]				
Cortical bone perforation				
No	10/33 (30.3)	0.476[c]	1	
Yes	5/23 (21.7)		0.639 (0.185–2.204)	0.478
Locularity				
Unilocular	9/40 (22.5)	0.133[d]	1	
Multilocular	7/17 (41.2)		2.411 (0.713–8.151)	0.157
Radiodensity[h]				
Radiolucent (RL)	5/14 (35.7)	0.436[d]	1	
Mixed (M)	14/48 (29.2)		0.741 (0.211–2.608)	0.641
Radiological limits				
Ill-defined	2/5 (40.0)	0.512[d]	1	
Well-defined	18/58 (31.0)		0.675 (0.104–4.396)	0.681
Tooth displacement				
No	8/24 (33.3)	0.594[c]	1	
Yes	8/30 (26.7)		0.727 (0.225–2.349)	0.595
Tooth root resorption				
No	18/57 (31.6)	0.479[d]	[e]	
Yes	0/2 (0)			–
Secondary aneurysmal bone cyst				
No	17/57 (29.8)	0.379[d]	1	
Yes	3/7 (42.9)		1.765 (0.356–8.748)	0.487

CI, confidence interval; OR, odds ratio.
[a] For the comparisons with χ^2 tests.
[b] For the odds ratio.
[c] Pearson χ^2 test.
[d] Fisher's exact test.
[e] In at least one case, the value of the weight variable was zero. Such cases are invisible to statistical procedures and graphs, which need positively weighted cases.
[f] Resection with continuity defect.
[g] All cases presented expansion of the surrounding bone. Therefore, analyses for this factor were not possible.
[h] 'Radiopaque' lesions were not considered here, as there was only one case for trabecular lesions.

Discussion

The aim of this study was to integrate the available data published in the literature on JOF into a comprehensive comparative analysis of their clinical and radiological features, as well as the frequency of recurrence. A review of pathological lesions is important because it provides information that can improve diagnostic accuracy, allowing pathologists and surgeons to make informed decisions and refine treatment plans to optimize clinical outcomes[7–11]. The entities under discussion here, JTOF and JPOF, are benign bone tumours of the craniofacial skeleton occurring predominantly in children and teenagers. More specifically for the group of ossifying fibromas, proper identification of these distinct entities is important not only for academic purposes, but also for proper diagnosis and therapeutic management[12].

It is important to call attention to a common mistake made by some authors. The number of publications with a seemingly wrong diagnosis or insufficient documentation was considerable. Just because the patient is young does not mean that the lesion is JOF. Moreover, the histopathological picture is very important for the consolidation of the diagnosis, together with the clinical and radiological features. Some cases described in the literature and that were listed by Makek[4] in his book did not fulfil the criteria for diagnosis as either JTOF or JPOF. Moser[13] and Krogius[14] were probably the first to describe probable cases of JOF. However, these cases were not included in the study analyses due to the absence of actual image data – it was possible to get hold of these articles, but they present only sketches of the histopathological examinations.

An important difference between the two types of JOF is the predominant anatomical site of the lesions. JPOF occurs

Table 4. Recurrence rate for psammomatoid juvenile ossifying fibroma, according to different factors—for the lesions with available information about both recurrence and the factors included here.

Factor	Recurrence/total (% recurrence)	*P*-value[a]	OR (95% CI)	*P*-value[b]
Treatment				
Curettage (C)	24/52 (46.2)	0.362[c]	0.700 (0.325–1.509)	0.363 (C vs. EO)
Enucleation only (EO)	21/56 (37.5)	0.004[c]	0.167 (0.044–0.628)	0.008 (C vs. EP)
Enucleation + curettage or peripheral osteotomy (EP)	3/24 (12.5)	<0.001[c]	[d]	- (C vs. MR)
Marginal resection (MR)	0/18 (0)	0.001[c]	[d]	- (C vs. SR)
Segmental resection[e] (SR)	0/16 (0)	0.025[c]	0.238 (0.063–0.896)	0.034 (EO vs. EP)
		0.002[c]	[d]	- (EO vs. MR)
		0.002[f]	[d]	- (EO vs. SR)
		0.176[f]	[d]	- (EP vs. MR)
		0.205[f]	[d]	- (EP vs. SR)
		[g]	[d]	- (MR vs. SR)
Anatomical location				
Maxilla/mandible	28/85 (32.9)	0.458[c]	1	
Paranasal sinuses	25/90 (27.8)		0.783 (0.410–1.494)	0.458
Bone expansion				
Yes	4/14 (28.6)	0.451[f]	1	
No	25/106 (23.6)		0.772 (0.223–2.675)	0.683
Cortical bone perforation				
No	12/54 (22.2)	0.309[c]	1	
Yes	10/31 (32.3)		1.667 (0.620–4.482)	0.312
Locularity				
Unilocular	17/68 (25.0)	0.848[c]	1	
Multilocular	7/26 (26.9)		1.105 (0.396–3.083)	0.848
Radiodensity[h]				
Radiolucent	6/15 (40.0)	0.129[f]	1	
Mixed	24/106 (22.6)		0.439 (0.142–1.357)	0.153
Radiological limits				
Ill-defined	2/4 (50.0)	0.252[f]	1	
Well-defined	26/110 (23.6)		0.310 (0.042–2.307)	0.253
Tooth displacement				
No	19/77 (24.7)	0.541[c]	1	
Yes	8/26 (30.8)		1.357 (0.509–3.618)	0.542
Tooth root resorption				
No	28/103 (27.2)	0.731[f]	[d]	
Yes	0/1 (0)			–
Secondary aneurysmal bone cyst				
No	23/92 (25.0)	0.081[f]	1	
Yes	7/15 (46.7)		2.625 (0.858–8.035)	0.091

CI, confidence interval; OR, odds ratio.
[a] For the comparisons with χ^2 tests.
[b] For the odds ratio.
[c] Pearson χ^2 test.
[d] In at least one case, the value of the weight variable was zero. Such cases are invisible to statistical procedures and graphs, which need positively weighted cases.
[e] Resection with continuity defect.
[f] Fisher's exact test.
[g] None of the cases recurred, either treated by marginal or segmental resection.
[h] 'Radiopaque' lesions were not considered here, as there were only three cases for psammomatoid lesions.

more frequently in the fronto-naso-orbito-ethmoidal region than JTOF, which predominantly affects the jaws, with a slight predilection for the maxilla, although the anatomical delimitations of the lesions are not always black and white. Some cases that mainly affected the maxillary sinuses also affected the ipsilateral nasal cavity or the orbit. It is not uncommon in cases that mainly affect the nasal cavity to have extensions into any paranasal sinus. The local invasion varies from 'bowing' or 'pushing' of the adjacent bony confines to invasion through the osseous delimiting walls, with extension into the adjacent anatomical compartments[15]. It is interesting to note that 60 (42.0%) JTOF and 58 (22.1%) JPOF cases involved the mandible. Therefore, they have to be considered in the differential diagnosis of benign fibro-osseous lesions in this location.

Another difference between the variants is that JPOFs are more commonly reported in adults than JTOFs and show a wider age distribution than JTOFs, which are predominantly seen in young patients. It has been suggested that these lesions may be present for an extended period of time, beginning in adolescence, but only manifest in adulthood once the lesion has attained an appreciable size, thus still qualifying as a juvenile lesion[5]. When all locations were compared together, the mean age of the patients with JPOF (18.9 ± 12.0 years) was significantly higher than that of the patients with JTOF (11.5 ± 6.0 years), which confirms previously published data[6].

In a study performed to evaluate and compare the computed tomography features of the two variants of JOF, Owosho

et al.[16] reported that both displayed a well-defined border, although JPOF exhibited a ground-glass pattern as an outer mantle with central radiolucency, a single mural nodule, or a solid homogeneous mass, whereas JTOF presented as a radiolucent lesion with irregular, scattered calcifications. We were not able to compare the radiological variations in as much detail as Owosho et al.[16], as the evaluation of many features in radiographs printed in articles is not always reliable, unless the authors have described them in the text, and not every publication provided computed tomography examination images as figures. However, it was observed in the present review that there were no striking differences between JTOFs and JPOFs with regard to the prevalence of locularity appearance on radiological examination, radiodensity, radiological limits, and cortical bone perforation.

Aneurysmal bone cyst formation has been reported in some cases. They develop initially as a focal myxoid change in the stroma with haemorrhage and osteoclastic giant cells, with gradual expansion and the formation of cysts with thin fibrous walls[12]. According to a large case series, these cysts tended to occur more commonly in younger patients in the first and second decades of life, and large aggressive maxillary lesions were commonly associated with these cyst formations[5]. The results of the present review indicate that secondary aneurysmal bone cysts are more prevalent in JPOF compared to JTOF, and lesions with these cysts had higher rates of recurrence in comparison to lesions without cysts, although the difference was found not to be statistically significant.

This review found that the surgical resection of JOFs resulted in a virtual absence of recurrence. Recurrence of these lesions has been associated with an incomplete excision due to the infiltrative nature of the tumour borders[5,6]. The present results also found that enucleation and curettage had a considerably high recurrence rate, regardless of the anatomical location or the variant type of the lesion. For the JTOFs, a significant reduction in recurrence was only observed when curettage was compared with marginal resection. However, enucleation complemented by ostectomy or curettage had low recurrence, and due to the low number of cases that received this treatment modality, the difference was not statistically significant. A more significant reduction in recurrence was observed for JPOFs treated by enucleation with adjunctive treatment (ostectomy or curettage) compared with curettage or enucleation. Therefore, enucleation followed by peripheral osteotomy should be the treatment of choice for both JOF variants in order to avoid the disfigurement usually associated with surgical resection. It has been recommended that the tumour mass should be removed down to the level of normal bone with preservation of the adjacent vital structures as much as possible[15]. Moreover, it has been recommended that resection should be considered in cases where there is recurrence, invasion of adjacent bony cavities, or where preservation of the inferior border is not possible[15]. Immediate reconstruction is not advised in these cases, as the prognosis is uncertain. In fact, 56.5% of the lesions reviewed here that recurred did so within 1 year after treatment.

Some studies have suggested that the aggressive growth and tendency to recur is age-related and is seen more frequently in the younger age groups[5,6]. However, no correlation was observed between age and recurrence. The results from these previous studies could have been related to the numbers of reported cases, which although quite large, were still smaller than the number of cases included in the present review.

This study has limitations. The first is the retrospective nature of the included studies. Due to the retrospective nature of the study, it was not possible to retrieve some relevant information, such as detailed radiological features, and there was a lack of detailed information on the histopathological JOF subtypes of the 85 cases reported by Johnson et al.[5], the inclusion of which would have improved the quality of the statistical analyses[17]. Second, many of the cases had a short follow-up, which could have led to an underestimation of the incidence of recurrence.

In conclusion, JOF lesions presented high rates of recurrence after treatment by curettage and enucleation only. Although the surgical resection of JOFs resulted in a virtual absence of recurrence, enucleation followed by peripheral osteotomy/curettage should be the treatment of choice for both JOF variants to avoid the disfigurement usually associated with surgical resection.

Funding

None.

Competing interests

None.

Ethical approval

Not applicable.

Patient consent

Not required.

Acknowledgements. We would like to thank the following people who provided us with some articles: Noko Reagan Mojela (Editorial Assistant, South African Dental Journal), Dr Douglas Brockmeyer, and Dr David R. Jordan. We would like to thank the librarians of Malmö University who helped us to obtain some articles. RSG is a research fellow at CNPq, Brazil.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijom.2019.06.029.

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Please cite this article in press as: Chrcanovic BR, Gomez RS. Juvenile ossifying fibroma of the jaws and paranasal sinuses: a systematic review of the cases reported in the literature, *Int J Oral Maxillofac Surg* (2019), https://doi.org/10.1016/j.ijom.2019.06.029