RESEARCH

Visual perception of multilocular radiolucent mandibular lesions quantified by morphometric analysis

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Objective: The aim of this study was to analyse the visual perceptions of different experts with respect to multilocular radiolucent lesions in circumstances when the diagnosis is either known or unknown.

Methods: 6 radiographs of ameloblastomas (AMELs), keratocystic odontogenic tumours (KOTs), central giant cell lesions (CGCLs) and myxomas (MIXs) were analysed by 16 dental experts [stomatologists/oral surgeons (SS) and dental radiologists (R)]. They delimited the lesions prior to having knowledge of the diagnosis (T1) and after 30 days, when they were aware of the histopathological results (T2). For each image, the following morphometric parameters were calculated: area (A), perimeter (P) and shape factor (SF); after image subtraction procedures (T1 – T2), the exclusive area (EA) of the non-overlapping delimited region was also calculated.

Results: For both groups, the T2 area was larger than the T1, although the EA of the SS group was higher than that of the R group independently of the type of lesion. The SF from the SS group was greater than that from the R group, and at T2 the SF values were higher for both groups. AMELs and MIXs showed larger SF and A values; the SS group tended to have the greatest changes in the delimitations of the lesions at T2.

Conclusions: The methodology allowed us to quantify differences in the spatial perceptions of professionals. The knowledge of the diagnosis and the expertise of examiners influenced the examiner's perception of the limits of the lesions independently of the actual biological behaviour of the lesion.

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Introduction

The radiographic examination has long been considered a key tool for identifying bone lesions within the maxillomandibular complex, which are traditionally very difficult to diagnose.¹ In this context, the diagnosis of radiolucent lesions is particularly challenging, as their prevalence is low and the images tend to share common features. In addition, this group of diseases has a wide range of aggressiveness and requires diverse types of treatments, from curettage for a simple bone cyst, which

has a high success rate, to enucleation with wide margins for ameloblastomas, which is associated with a worse prognosis. In these cases, the visual acuity of maxillofacial radiologists, which is responsible for determining the delimitation of the lesion's borders, and of oral surgeons, which is responsible for conduction surgery, in combination with other factors, including the type of the disease, the professional's area of expertise and their previous knowledge concerning the diagnosis, may be central to the success of the treatment.

On the other hand, digital radiology has introduced the possibility of manipulating visual information to enhance or to extract discriminant characteristics that

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allow for improvement in the diagnostic process compared with conventional techniques. These technologies allow the radiologist to modify the images by manipulating the level of brightness, contrast and magnification as well as other image-processing management. In addition, the software could automatically analyse these images, thereby providing additional data. This information, once incorporated routinely with an artificial intelligence system, could result in great improvements in the diagnostic process.^{2,3}

When characterizing bone lesions, size and shape are considered important parameters for defining the type of disease and consequently its potential aggressiveness,¹ but they are often assessed subjectively. To circumvent this problem, images of bone lesions can easily be converted to digital images that can then be analysed using computerized morphometric analysis. In this case, comparisons of the shape factor (circularity) and lesion area could assist in determining edge irregularities and lesion size. This type of analysis has been used successfully to characterize benign and malignant breast lesions using images from ultrasounds.⁴⁻⁶ In addition, the combination of image subtraction procedures and morphometric analysis permits the quantification and localization of these changes.⁷

In the oral and maxillofacial area, the experience of different dental specialists, including pathologists, stomatologists, radiologists and oral surgeons, is quite variable, which could certainly influence the perception of the limits and architecture of the bone lesions of the maxillamandibular complex. The identification and quantification of these differences could be important for communication and standardization of the knowledge and the procedures employed in the treatments. Digital image processing, which allows for the delimitation of lesions in a non-geometric manner and the resulting quantification of the morphometric parameters, such as area, perimeter and shape, using specialized software programs could contribute to increased understanding of the differences in perception among different professionals and circumstances of the diagnosis. Therefore, our objective was to analyse the visual perceptions of the different experts on multilocular radiolucent lesions with diverse aggressiveness on occasions when the diagnosis was known or not.

Materials and methods

Selection of conventional panoramic radiographs

Three radiologists selected 24 conventional panoramic radiographs (Instrumentarium OP100®, Tuusula, Finland, and panoramic Kodak 15 × 30 film, Rochester, NY), stored in the hospital Stomatology Department archives, from different patients with multilocular radiolucent lesions whose histopathological examinations confirmed the diagnosis of ameloblastoma (AMEL) ($n = 6$), keratocystic odontogenic tumour (KOT) ($n = 6$), central giant cell lesion (CGCL)

($n = 6$) or myxoma (MIX) ($n = 6$). These radiologists had more than 5 years of experience and were not included in the group of enrolled expert professionals. Lesions of different size and location were chosen that were representative of radiographic aspects of each lesion group, six images being sufficient to categorize the majority of clinical outcomes of these diseases. Panoramic radiographs with good contrast, correct alignment on the film and lesion images without any interference were selected.

This project was approved by the ethics committee of the university.

Digitalization of the radiographs and processing of the images

The selected radiographs were digitalized at 600 dpi spatial resolution and 256 greyscale (8 bit depth) contrast resolution, using the Scan Maker i800 scanner (Microtek Lab, Carson, CA) and stored in tagged image file format.

Subsequently, the images were adjusted using the contrast and bright tools of Adobe Photoshop 6.0® software (Adobe, San Jose, CA) to correct minimal overexposure or underexposure of the radiographs.⁸ The examiners were not allowed to control the brightness and the contrast of images.

The professionals analysed the images using the same computer laptop HP® Pavilion dv6000 with 667 MHz AMD Turion 64 CPU, 2 GB of RAM, HD of 120 GB, and 15.4, screen with 1280 × 800 pixels of spatial resolution (HP Company, Palo Alto, CA).

Experimental groups

Two groups of dentists were selected to evaluate the images: eight experts in stomatology and/or oral surgery were enrolled in the stomatologists/oral surgeons (SS) group and eight dental radiologists were in the radiologists (R) group. The individuals were randomly invited from radiological clinics and hospitals. All of them had more than 5 years of experience in the area.

Radiographs images evaluation

The images were loaded using the ImageLab 3000® software (Diracom Bio-Informática, São Paulo, Brazil) and visualized, controlling for the inclination and distance between the computer screen and the professionals' eyes and in a room with the same light intensity (lights dimmed). All participants received training on the available tools of the software prior to starting. The analysis of the cases was carried out on two occasions: before ($T1$) and after ($T2$) the information concerning the correct diagnosis was related to the examiner. In each moment ($T1$ and $T2$), the lesions were delimited on digitalized radiography images by examiners using a digitalizing Tablet Genius G-Pen 4500 (KYE Systems Corp., San Chung, Taiwan), which allowed for contouring of the lesions in an easy and accurate manner.

Based on their delimited contours, ImageLab calculated the following parameters for each image: area (A), perimeter (P) and shape factor (SF). SF ($4\pi \times \text{area} / \text{perimeter}^2$) is a parameter that describes contour irregularity independently of an object's dimensions.^{6,9,10} Lower SF values were observed in areas with larger numbers of recesses and saliencies whose perimeters were maximized compared with their areas. SF values can range between 0, which represents an extremely irregular region, and 1, which represents a perfect circle. The higher the level of margin scalloping, the smaller the SF, independent of the lesion size. Thus, regions with identical shapes but different sizes maintain a constant relationship between the area and perimeter squared.

At *T1*, each examiner formulated a diagnostic hypothesis for each case. The range of time between *T1* and *T2* was 30 days. The analysis at *T1* and *T2* was carried out in the same room under the same intensity of light using the same computer and screen position standardizations. In both moments, the sequence of the analysed images was identical for each examiner and was completed on the same day.

Data collection and interpretation

Using ImageLab software, the delimited contours from *T1* and *T2* were combined in the same image (Figure 1). Based on the differences observed after subtracting one image delimitation from the other (Figure 1d = Figure 1c – Figure 1b), the differences in area (exclusive area, EA) of the non-overlapping regions of each lesion were calculated. This procedure was important to ensure that the exact regions of the lesions related to variations in perception between the two time points (*T1* and *T2*) that were analysed. In contrast to the differences in area that were calculated separately ($A2 - A1$, at *T2* and *T1*, respectively), the exclusive parameter (*i.e.* the area of the non-overlapping regions) takes into account the positions of the delimitations in addition to their magnitude. In this way, it was possible to differentiate between cases exhibiting identically sized areas with inadequate overlap.

The two overlapping images (*T1* and *T2*) were the same and therefore the correspondence of the position was perfect. The software tool that overlaps images allows changing the position of one in relation to another and verifying the result of subtraction continuously. When the overlapping is perfect, the pixels did not suffer; alterations are shown with the grey tone value equal to 128 (subtraction formula = $128 + T1 - T2$).

In addition, A, P and SF were quantified separately for the *T1* and *T2* contours of each participant for all 24 images.

Statistical tests

The ANOVA statistical test with repeated measures on one factor was employed to determine whether there was statistical significance between A, EA, the differences in

areas ($A2 - A1$), the perimeter (P), the differences in perimeters ($P2 - P1$), the SF and the differences in shape factors ($SF2 - SF1$) considering the type of professional and the lesions. The type of professional was analysed as a between-subject factor, and the repeated measures of different radiographs grouped by type of lesion and moment were analysed as within-subject factors. The interactions between factors were also considered. The *post hoc* Bonferroni multiple comparison test was used to analyse the difference between pairs of lesions. The normality of data was verified using the Kolmogorov–Smirnov Z-test. The variables considered as non-normal were submitted to square root transformation. The homogeneity of variance was analysed by Levene's statistical test and sphericity was analysed by Mauchly's test. The *F*-value of variables with sphericity not assumed was corrected using the Huynh–Feldt method. In addition, the EA mean and the mean difference of P, A and SF of each lesion were compared using the non-parametric Mann–Whitney *U*-test, taking into consideration the type of professional as the grouping factor. A *p*-value less than 0.05 was considered significant and the software employed for statistical analysis was SPSS 16.0 (SPSS Inc., Chicago, IL).

Results

Upon analysis of the differences in the delimited area involving the *T1* and *T2* moments (Table 1), EA was observed to be significantly different between the type of professionals ($p < 0.05$). The differences in the delimited area represented by the SS group ($3.6 \pm 5.2 \text{ cm}^2$) were greater than those of the R group ($1.5 \pm 1.7 \text{ cm}^2$). Comparing the EA of each lesion in relation to the type of professional, it was observed that this discrepancy was associated with significant differences in the magnitude of EA of MIX ($p < 0.01$), CGCL ($p < 0.05$) and KOT ($p < 0.01$), although there was no significant difference in EA between the types of lesions ($p = 0.279$).

It was possible to observe that the areas of *T2* moment ($25.7 \pm 11.6 \text{ cm}^2$) had higher values than *T1* ($24.5 \pm 10.8 \text{ cm}^2$) ($p < 0.01$), which was independent of the expertise of the professional ($p = 0.763$) (Table 2). The lesions with the highest mean values of delimitation were MIX and AMEL followed by KOT and CGCL ($p < 0.01$) and there was significant interaction ($p < 0.01$) between type of lesion and area delimited by the type of professional (SS, MIX > AMEL > KOT > CGCL *vs* R, AMEL = MIX > KOT > CGCL) (Table 2). This divergence occurred mainly in the differences of delimitation of the lesions AMEL (SS: 26.6 ± 10.0 *vs* R: 28.5 ± 10.2 , $p < 0.05$) and KOT (SS: 25.1 ± 9.3 *vs* R: 24.0 ± 7.8 , $p < 0.05$) carried out by two types of professionals.

Analysing the differences of areas delimited at the two moments ($A2 - A1$) (Table 2), it was observed that there was no significant association with the type

Figure 1 (a) An example of the delimitation of the lesion; (b,c) demarcation of the area at two different moments ($T1$ and $T2$); (d) delimited lesion at $T1$ overlapped by the lesion delimited at $T2$ (for calculating the exclusive area and perimeter)

of professional ($p = 0.378$) or the type of lesion ($p = 0.279$). However, comparing the differences of areas of each lesion in relation to type of professional, it was noticed that the SS group tended to make the greatest changes in the delimitations of the CGCL lesions ($p < 0.01$).

In relation to perimeter, $T2$ perimeters had similar values to $T1$ ($p = 0.454$), but there was significant difference in relation to expertise of the professional ($p < 0.05$) and type of lesion (KOT > AMEL = MIX > CGCL; $p < 0.01$; Table 3).

When perimeter differences between the two moments ($P2 - P1$) were considered, there was no

statistical difference associated with type of professional ($p = 0.420$) and type of lesion ($p = 0.951$). However, when this difference ($P2 - P1$) was analysed for type of lesion and type of professional, the CGCL showed statistical difference between SS and R ($p < 0.05$).

When the SF values were analysed (Table 4), it was observed that the SF mean values of the SS group ($p < 0.01$) or of the $T2$ moment ($p < 0.05$) were significantly higher than the R group and the $T1$ moment respectively. The greatest SF values were found for AMEL cases, and the lowest mean was found for KOT ($p < 0.01$) for both groups of examiners. The numeric sequence for

Table 1 Analysis of the exclusive area (EA)

Variable	Factor	Subgroups	n	Mean (cm ²)	Median (cm ²)	SD (cm ²)
EA (cm ²)	Type of professional $p < 0.05^a$	SS	192	3.6	1.7	5.2
		R	192	1.5	1.0	1.7
	Type of lesion $p = 0.279$	MIX	96	2.9	1.5	4.7
		AMEL	96	2.6	1.5	3.8
		CGCL	96	2.5	1.0	4.2
		KOT	96	2.2	1.2	3.0
	Mean of EA related to type of lesion	MIX $p < 0.01^b$	SS	8	4.3	2.1
			R	8	1.5	0.5
		AMEL $p = 0.442$	SS	8	3.0	2.5
			R	8	2.0	0.9
		CGCL $p < 0.05^a$	SS	8	3.8	2.6
			R	8	1.2	0.5
		KOT $p < 0.01^b$	SS	8	3.3	2.2
			R	8	1.0	0.4

AMEL, ameloblastoma; CGCL, central giant cell lesion; KOT, keratocystic odontogenic tumour; MIX, myxoma; R, radiologists; SD, standard deviation; SS, surgeons/stomatologists.

Lesion data are shown in inverse order of magnitude.

^aStatistically significant at $p < 0.05$.

^bStatistically significant at $p < 0.01$.

SF values was AMEL > MIX > CGCL > KOT ($p < 0.01$). There was no difference in the levels of changes in SF (SF2 – SF1) between the two moments associated with the type of professional ($p = 0.696$) or type of lesion

($p = 0.08$). Comparing the difference in SF of each lesion in relation to type of professional, it was noticed that there was no significant difference in the level of changes in any lesion.

Table 2 Analysis of the area (A) and of the difference in area (A2 – A1) at T1 and T2

Variables	Factor	Subgroups	n	Mean (cm)	Median (cm)	SD (cm)
Area (cm)	Time point $p < 0.01^a$	T1	384	24.5	24.3	10.8
		T2	384	25.7	25.0	11.6
	Type of professional $p = 0.763$	SS	384	25.0	23.1	12.0
		R	384	25.2	25.4	10.4
	Type of lesion $p < 0.01^a$	MIX	192	28.3 ^b	28.0	14.68 ^b
		AMEL	192	27.6 ^b	28.9	10.1 ^c
		KOT	192	24.5 ^c	24.6	8.62 ^d
		CGCL	192	19.8 ^d	20.5	8.28 ^c
	Interaction type of lesion and professional $p < 0.01^a$	SS	MIX	96	28.9 ^b	26.7
			AMEL ^e	96	26.6 ^c	25.9
			KOT ^f	96	25.1 ^d	23.3
			CGCL	96	19.3 ^g	18.5
		R	AMEL ^e	96	28.5 ^b	31.0
			MIX	96	27.7 ^b	28.6
			KOT ^f	96	24.0 ^c	24.9
			CGCL	96	20.3 ^d	22.9
Difference in area: A2 – A1 (cm ²)	Type of professional $p = 0.378$	SS	192	Mean (cm ²) 1.5	Median (cm ²) 0.3	SD (cm ²) 6.47
			192	0.9	1.0	3.73
	Type of lesion $p = 0.279$	MIX	96	1.88	0.85	7.14
		CGCL	96	1.37	0.92	5.71
		AMEL	96	0.77	0.97	3.84
		KOT	96	0.85	0.84	3.65
	Mean of A2 – A1 Related to type of lesion	MIX $p = 0.382$	SS	8	2.3	3.1
			R	8	1.4	0.5
		AMEL $p = 0.878$	SS	8	0.6	0.8
			R	8	0.9	1.0
		CGCL $p < 0.05^h$	SS	8	2.5	2.6
			R	8	0.3	0.4
		KOT $p = 0.959$	SS	8	0.7	0.9
			R	8	1.0	1.1

AMEL, ameloblastoma; CGCL, central giant cell lesion; KOT, keratocystic odontogenic tumour; MIX, myxoma; R, radiologists; SD, standard deviation; SS, surgeons/stomatologists; T1, before knowledge of the correct diagnosis; T2, after being made aware of the correct diagnosis.

^aDelimitations with different sizes of areas considered statistically significant at $p < 0.01$.

^{b,c,d,g}Means for groups in homogeneous subsets are displayed with the same letters.

^{e,f}Lesions (SS vs R) with different sizes of areas considered statistically significant at $p < 0.05$.

^hDelimitations with different sizes of areas considered statistically significant at $p < 0.05$.

ⁱData of lesions are shown in inverse order of magnitude.

Table 3 Analysis of the perimeter (P) and of the difference of perimeter (P2 – P1) at T1 and T2

Variables	Factor	Subgroups	n	Mean (cm)	Median (cm)	SD (cm)
Perimeter (cm)	Time point $p = 0.454$	T1	384	27.6	28.3	7.6
		T2	384	27.9	19.0	7.3
	Type of professional $p < 0.05^a$	SS	384	27.3	26.9	8.2
		R	384	28.3	29.5	6.5
		KOT	192	29.4 ^b	31.9	6.5
	Type of lesion $p < 0.01^d$	MIX	192	28.5 ^c	30.6	8.2
		AMEL	192	27.7 ^c	27.1	6.3
		CGCL	192	25.5 ^e	25.2	8.0
		SS	192	0.34	−0.04	6.19
		R	192	0.12	0.03	2.08
Difference of perimeter: P2 – P1 (cm)	Type of professional $p = 0.420$	MIX	96	0.65	0.10	3.97
		CGCL	96	0.32	0.24	7.29
		AMEL	96	−0.17	−0.17	3.03
		KOT	96	0.12	−0.06	2.71
	Type of lesion $p = 0.951$	SS	8	0.83	1.00	2.47
		R	8	0.47	0.51	0.42
		AMEL	8	−0.48	−0.58	2.01
		R	8	0.13	0.38	0.65
	Mean of P2 – P1 related to type of lesion	CGCL	8	0.84	1.45	3.37
		SS	8	−0.20	−0.06	1.79
		R	8	0.18	−0.10	1.70
		R	8	0.06	0.07	0.27
	$p = 0.573$	SS	8	0.83	1.00	2.47
		R	8	0.47	0.51	0.42
		AMEL	8	−0.48	−0.58	2.01
		R	8	0.13	0.38	0.65
	$p = 0.234$	CGCL	8	0.84	1.45	3.37
		SS	8	−0.20	−0.06	1.79
		R	8	0.18	−0.10	1.70
		R	8	0.06	0.07	0.27

AMEL, ameloblastoma; CGCL, central giant cell lesion; KOT, keratocystic odontogenic tumour; MIX, myxoma; R, radiologists; SD, standard deviation; SS, surgeons/stomatologists. T1, before knowledge of the correct diagnosis; T2, after being made aware of the correct diagnosis.

^aData considered statistically significant at $p < 0.05$.

^{b,c,e}Means in inverse order of magnitude for groups in homogeneous subsets are displayed with the same letters.

^dData considered statistically significant at $p < 0.01$.

Discussion

Because of the large number of benign tumours of the maxillomandibular complex and the relative similarity between them, the diagnostic accuracy for these types of tumours based on radiographic characteristics alone is difficult to determine.¹¹ Therefore, computerized

resources that facilitate increased discrimination and comprehension of bone diseases of this area of the face are welcome and necessary. This study demonstrated that an innovative method of bone lesion analysis could help in the quantification of image perception in radiology. Our findings showed that the existence of significant differences in the delimitation of bone

Table 4 Analysis of the shape factor (SF) and of the difference of SF (SF2 – SF1) at T1 and T2

Variables	Factor	Subgroups	n	Mean	Median	SD
SF	Time point	T1	384	0.404	0.393	0.093
		T2	384	0.413	0.401	0.104
	Type of professional	SS	384	0.424	0.422	0.106
		R	384	0.392	0.380	0.088
		AMEL	192	0.450 ^c	0.444	0.095
	Type of lesion	MIX	192	0.425 ^d	0.428	0.099
		CGCL	192	0.390 ^e	0.379	0.093
		KOT	192	0.369 ^f	0.351	0.088
		SS	192	0.007	0.008	0.099
		R	192	0.010	0.013	0.042
Difference of SF (SF2 – SF1)	Type of professional	MIX	96	−0.002	−0.002	0.071
		CGCL	96	0.006	0.003	0.102
		AMEL	96	0.018	0.014	0.061
		KOT	96	0.013	0.019	0.063
	Type of lesion	SS	8	−0.003	0.000	0.034
		R	8	−0.001	−0.002	0.018
		AMEL	8	0.023	0.031	0.035
		R	8	0.013	0.010	0.013
	SF2 – SF1	CGCL	8	0.009	0.012	0.026
		SS	8	0.013	0.015	0.016
		R	8	0.005	0.008	0.025
		R	8	0.020	0.020	0.013
	Related to type of lesion	SS	8	−0.003	0.000	0.034
		R	8	−0.001	−0.002	0.018
		AMEL	8	0.023	0.031	0.035
		R	8	0.013	0.010	0.013
	Mean of	CGCL	8	0.009	0.012	0.026
		SS	8	0.013	0.015	0.016
		R	8	0.005	0.008	0.025
		R	8	0.020	0.020	0.013

AMEL, ameloblastoma; CGCL, central giant cell lesion; KOT, keratocystic odontogenic tumour; MIX, myxoma; R, radiologists; SD, standard deviation; SS, surgeons/stomatologists; T1, before knowledge of the correct diagnosis; T2, after being made aware of the correct diagnosis.

^aData considered statistically significant at $p < 0.05$.

^bData considered statistically significant at $p < 0.01$.

^{c,d,e,f}Means in inverse order of magnitude for groups in homogeneous subsets are displayed with the same letters.

lesions was associated with the experience of different dental experts, type of lesions and previous knowledge of the histopathological diagnosis.

In our experiment, the differences in the percentages of correct diagnoses between both groups were small. A previous experiment had already confirmed that for radiolucent lesions, diagnostic accuracy is independent of the type of specialist and of the type of lesion assessed.¹²

In terms of morphometric perception, the mean EA (Table 1) for the SS group was significantly higher than that for the R group ($p < 0.05$). In this study, we established the EA value between $T1$ and $T2$ when the $T1$ contour was delimited before the examiners were aware of the histopathological diagnosis and the $T2$ contour after the examiners were aware of the histopathological diagnosis. In this way, we could infer that after knowing what the disease was, the SS group reconsidered the dimensions of the lesions and increased their size and/or modified the position of the delimitation in a major way compared with the R group. The discrepancy was more pronounced in the delimitation of the MIX, KOT and CGCL. The second hypothesis is more probable since the simple variation in area between the two time points ($A2 - A1$) (Table 2), related to type of professional, was not significantly different ($p = 0.378$).

As such, the different experiences of the professionals might have influenced the delimitation of the aggressive lesions,^{13–18} although it is not possible to determine if the $T2$ contours were corrected or overestimated. We also cannot eliminate the possibility that the SS group could not delimitate the lesion accurately on the radiograph because they were not experts in radiology.

It is noteworthy that there was no difference in EA between the four types of lesions analysed ($p = 0.279$), which suggests an inappropriate behaviour (Table 1). For example, the CGCL is considered a disease with low aggressiveness, the treatment of which is conservative for the majority of cases; however, the EA calculated was similar to the others believed to be more aggressive.¹⁵

The greatest standard deviation value for the area was encountered for MIX (Table 2) and this was probably because of the great radiographic variability that this lesion possesses when analysed using conventional panoramic radiographs, mainly due to the irregularity of the edges and the absence of cortical involvement¹³ that sometimes suggests a malignant lesion.^{17–20} When the edges were undefined, the SS group had a tendency to be more aggressive in the delimitation of the lesions, increasing the delimitation of the borders, and also changing the locale of the delimitation after becoming aware of the histopathological diagnosis (only showed by EA, in Table 1), possibly as a function of the success of the treatment (with low recurrence), which is directly correlated with the extension of surgical margins.¹⁹

KOT is the lesion with lower discrepancy values between $T1$ and $T2$ (Tables 1–3); this was probably

because of the precise limits obtained due to the presence of a radiopaque halo, a finding that was also reported by Chuenchompoonut *et al*²¹ in 2003.

In this sample of lesions, AMEL and MIX had a higher mean size than CGCL and KOT (Table 2). In some reviews, the sizes of the lesions were consistent with our findings.^{19,22–27}

When analysing the area mean values at the two time points (Table 2), both professionals increased the size of the lesions at $T2$, independently of the type of the lesion. However, when this variable was analysed taking into consideration the type of professional and type of lesion, a significant difference was observed for CGCL. The R group was more coherent when delimitating CGCL than the SS group, and this may indicate a different perception in relation to this type of lesion.

With regard to SF (Table 4), the highest values were found for AMEL cases, while the smallest were found for KOT in both groups of examiners. Notably, lesions that were approximated to be closer to one were those with forms similar to that of a circle. However, when P grew more quickly than the A, as occurs in scalloped lesions, the SF decreased. This finding confirms the higher irregularity of edges in KOT cases, where scalloping is a key feature of the lesion.²⁸ The sequence of decreasing values for the lesions was AMEL, MIX, CGCL, KOT ($p < 0.01$). It is possible to speculate that AMELs have a more rounded shape than the other lesions.

Our results also showed that after having knowledge of the diagnosis at $T2$, the mean SF was significantly higher than that at $T1$ ($p < 0.05$). In addition, the SS group had a higher mean than the R group ($p < 0.01$), indicating that the SS group delimited the lesion considering the therapeutic indication only and not the biological behaviour, although they delimited the lesions to have a more regular shape. The R group proved to be more careful when delimiting the lesions. Table 3 also shows that the mean values of perimeter for the R group were higher than for the SS group ($p < 0.05$).

The use of computers as tools for diagnosing disease processes is a natural evolution of the technology used in dental surgeries, and future studies that analyse how dental professionals view lesions and how they extract and discriminate data are necessary.²⁹ Based on our study, it is reasonable to conclude that the different specializations of the enrolled professionals did affect their judgement of the spatial resolution of the lesions. Oral surgeons and stomatologists had a tendency to reconsider the delimitation of the lesions after becoming aware of their true diagnosis, making it more regular at $T2$, independent of the nature of the lesion. On the other hand, the selected lesions could be classified into two clusters based on their shape and size. AMELs and MIXs were more regular and larger than the rougher and smaller KOTs and CGCLs.

The differences in the findings between the two groups indicate that lesion delimitations may be

possibly overestimated or underestimated when treated. Thus, it may prove advantageous to identify these discrepancies and standardize the different perceptions between professionals, which may increase the chances of curing or decreasing the sequelae of surgical treatments.

References

- O'Reilly M, O'Reilly P, Todd CE, Altman K, Schafner K. An assessment of the aggressive potential of radiolucencies related to the mandibular molar teeth. *Clin Radiol* 2000; **55**: 292–295.
- van der Stelt PF. Better imaging: the advantages of digital radiography. *J Am Dental Assoc (1939)* 2008; **139**(Suppl.): 7S–13S.
- Borra RC, Andrade PM, Correa L, Novelli MD. Development of an open case-based decision-support system for diagnosis in oral pathology. *Eur J Dent Educ* 2007; **11**: 87–92.
- Calas MJG, Alvarenga AV, Gutfilen B, Pereira WCA. Evaluation of morphometric parameters calculated from breast lesion contours at ultrasonography in the distinction among BI-RADS categories. *Radiol Bras* 2011; **44**: 289–296.
- Pohlman S, Powell KA, Obuchowski NA, Chilcote WA, Grundfest-Broniatowski S. Quantitative classification of breast tumors in digitized mammograms. *Med Phys* 1996; **23**: 1337–1345.
- Hayakawa Y, Wakoh M, Fujimori H, Ohta Y, Kuroyanagi K. Morphometric analysis of image distortion with rotational panoramic radiography. *Bull Tokyo Dent Coll* 1993; **34**: 51–58.
- Carvalho FB, Goncalves M, Guerreiro-Tanomaru JM, Tanomaru-Filho M. Evaluation of periapical changes following endodontic therapy: digital subtraction technique compared with computerized morphometric analysis. *Dentomaxillofac Radiol* 2009; **38**: 438–444.
- Gormez O, Yilmaz HH. Image post-processing in dental practice. *Eur J Dent* 2009; **3**: 343–347.
- Karslioglu Y, Celasun B, Gunhan O. Contribution of morphometry in the differential diagnosis of fine-needle thyroid aspirates. *Cytometry B Clin Cytom* 2005; **65**: 22–28.
- Tomlinson CW. Left ventricular geometry and function in experimental heart failure. *Can J Cardiol* 1987; **3**: 305–310.
- Theodorou SJ, Theodorou DJ, Sartoris DJ. Imaging characteristics of neoplasms and other lesions of the jawbones: part 2. Odontogenic tumor-mimickers and tumor-like lesions. *Clin Imaging* 2007; **31**: 120–126.
- Raitz R, Correa L, Curi M, Dib L, Fenyó-Pereira M. Conventional and indirect digital radiographic interpretation of oral unilocular radiolucent lesions. *Dentomaxillofac Radiol* 2006; **35**: 165–169.
- Schneck DL, Gross PD, Tabor MW. Odontogenic myxoma: report of two cases with reconstruction considerations. *J Oral Maxillofac Surg* 1993; **51**: 935–940.
- Curi MM, Dib LL, Pinto DS. Management of solid ameloblastoma of the jaws with liquid nitrogen spray cryosurgery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997; **84**: 339–344.
- Katz JO, Underhill TE. Multilocular radiolucencies. *Dent Clin North Am* 1994; **38**: 63–81.
- Meara JG, Shah S, Li KK, Cunningham MJ. The odontogenic keratocyst: a 20-year clinicopathologic review. *Laryngoscope* 1998; **108**: 280–283.
- Chow HT. Odontogenic keratocyst: a clinical experience in Singapore. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998; **86**: 573–577.
- Kaffe I, Naor H, Buchner A. Clinical and radiological features of odontogenic myxoma of the jaws. *Dentomaxillofac Radiol* 1997; **26**: 299–303.
- Noffke CE, Raubenheimer EJ, Chabikuli NJ, Bouckaert MM. Odontogenic myxoma: review of the literature and report of 30 cases from South Africa. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007; **104**: 101–109.
- Zhang J, Wang H, He X, Niu Y, Li X. Radiographic examination of 41 cases of odontogenic myxomas on the basis of conventional radiographs. *Dentomaxillofac Radiol* 2007; **36**: 160–167.
- Chuenchompoonut V, Ida M, Honda E, Kurabayashi T, Sasaki T. Accuracy of panoramic radiography in assessing the dimensions of radiolucent jaw lesions with distinct or indistinct borders. *Dentomaxillofac Radiol* 2003; **32**: 80–86.
- Zhao Y, Liu B, Han QB, Wang SP, Wang YN. Changes in bone density and cyst volume after marsupialization of mandibular odontogenic keratocysts (keratocystic odontogenic tumors). *J Oral Maxillofac Surg* 2011; **69**: 1361–1366.
- Gungormus M, Akgul HM. Central giant cell granuloma of the jaws: a clinical and radiologic study. *J Contemp Dent Pract* 2003; **4**: 87–97.
- Stavropoulos F, Katz J. Central giant cell granulomas: a systematic review of the radiographic characteristics with the addition of 20 new cases. *Dentomaxillofac Radiol* 2002; **31**: 213–217.
- Forssell K, Sorvari TE, Oksala E. A clinical and radiographic study of odontogenic keratocysts in jaws. *Proc Finn Dent Soc* 1974; **70**: 121–134.
- Chapelle KA, Stoelinga PJ, de Wilde PC, Brouns JJ, Voorsmit RA. Rational approach to diagnosis and treatment of ameloblastomas and odontogenic keratocysts. *Br J Oral Maxillofac Surg* 2004; **42**: 381–390.
- Fregnani ER, da Cruz Perez DE, de Almeida OP, Kowalski LP, Soares FA, de Abreu Alves F. Clinicopathological study and treatment outcomes of 121 cases of ameloblastomas. *Int J Oral Maxillofac Surg* 2010; **39**: 145–149.
- Stoelinga PJ. Long-term follow-up on keratocysts treated according to a defined protocol. *Int J Oral Maxillofac Surg* 2001; **30**: 14–25.
- Krupinski EA. Technology and perception in the 21st-century reading room. *J Am Coll Radiol* 2006; **3**: 433–440.