Volume Analysis a Novel Tool to Determine Mandibular Cyst Dimensions Using CBCT Technique

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To evaluate a method of creating three-dimensional representations of mandibular cysts on the cone beam computed tomography (CBCT) data and the data obtained following the evaluation according to Archimede's principle. A total of 10 mandible with different bone defects miming cysts took part in this study. CBCT scans were obtained from all mandibles and saved in the Digital Imaging and Communications in Medicine (DICOM) format. Data were analysed by two observers: a general dentist and a maxillofacial surgeon. The accuracy of the two methods in assessing cyst volume was compared. There are no major differences between the analysis performed on CBCT data and the real volume of the simulated cystic lesions. Also, there were found differences between the observers. Our results demonstrated the rehabilitee of CBCT scans and volume evaluation of the bone defects. In addition, this study may improve surgical planning and outcomes by knowing the exact volume of grafting material needed prior to the surgical intervention.

Keywords: mandibular cyst, CBCT, bone defects

The diagnosis and management of endodontic pathology is reliant on radiography. However it has inherent limitations, such as the three-dimensional (3D) anatomy of the area that is radiographed is compressed into a two-dimensional (2D) image. It also has the disadvantage of magnification, distortion and superimposition. The introduction of maxillofacial cone beam computed tomography (CBCT) in 1996 provided the first clinically practical technology demonstrating application of 3D imaging for endodontic considerations [1]. This technology has improved the efficiency of oral and maxillofacial surgeon in private offices, where access to cross-sectional imaging has now become quicker and easier than in a hospital-based practice. Prior to the introduction of CBCT, panoramic radiography was the most common imaging tool in private oral and maxillofacial surgery offices. While oral and maxillofacial surgeons have successfully practised using panoramic radiography, the limitation of this imaging technique includes variable magnifications, distortions, superpositions of structures and suboptimal imaging of structures not located in the focal area. CBCT has overcame these limitations. Depending on the field of view, CBCT scans show a large area of the facial skeleton beyond the limits of a panoramic radiography or a small area of focused clinical interest. As the CBCT slices can be reformatted and viewed in multiple possible orientation anatomic structures are not superimposed [2, 3].

CBCT scanning machines have made possible, both physically and financially, the elimination of the inherent limitations of the radiographically exam. Easier access to interoffice scanners allows the relief of patient's acceptance and use for the treating surgeon. Prior to the introduction of CBCT, multiplane views were obtained primarily with multi-detector CTs (MDCT) and magnetic resonance (MRI). Physical dimensions and costs of MDCT and MRI equipment are prohibitive for installation in a typical OMS office. Smaller physical dimension, lower cost and easier operation have led to rapid acceptance of CBCT units. There are many instances where an oral and maxillofacial surgeon may use a reliable CBCT scan instead of a MDCT, even the MDCT might otherwise have been chosen to provide diagnostic information. The need of MDCT and MRI examinations in oral surgery is not, even though the quality of CBCT images could be better than MDCT scans [3, 4].

A study that evaluated the image quality of bone structures acquired by five different CBCT machines and one MDCT machine showed that the image quality of one CBCT machine was superior to that from tested MDCT machine while imagines from other CBCT units were comparable to the test MDCT imagines [4].

In evaluation cysts or benign tumours, intraoral or panoramic radiographies show the two dimensions of the lesion. Observation of the third dimension, i.e bucco-lingual extension of a lesion, requires additional radiographies obtained at 90 degrees from the original view. In contrast, all three dimensions are recorded by the multiplane (axial, coronal and sagittal planes) imaging of CBCT. Such multiplane views provide important information on the presence and extent of bone resorptions, sclerosis of neighbouring bone, cortical expansion and internal or external calcification and proximity to other vital anatomy [3, 5].

The radicular cyst is a true cyst which is the most common odontogenic cystic lesion of inflammatory origin

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(60%). Its cystic lining of derived from the cell rest Malassez. It occurs as a consequence of pulpal necrosis secondary to caries, trauma or periodontal disease. Radicular cysts are slow growing and symptomless unless secondary infected [6, 7].

In a two-dimensional radiography, radicular cysts appear as round, pear or ovoid shaped unilocular radiolucency associated with the periapex of the offending tooth, outlined by a narrow radiopaque margin. The cyst may adjacent teeth or cause mild resorption. A review of the literature suggests that two-dimensional radiographies are unable to clearly demonstrate three-dimensional problems. The limitation to two-dimensional radiographies includes superimposition of three-dimensional anatomy as well as possible exposure or geometric errors [7, 8].

At CBCT evaluation multiplane sections are preferred when examining cysts or tumours deep in the tissues. If the lesion borders can be clearly seen, then multiple extraoral plain film radiographies oriented at 90 degrees to each other can provide adequate information of the size of a lesion. Information of the spatial relationship of the lesion with other anatomic landmarks on such imagines is limited and often difficult to interpret [9].

Newer CBCT units allow slice thickness to be as low as 0,1 mm. These thin slices allow better visualisation of the bony margins of a lesion. Oral and maxillofacial surgeons could depend on panoramic radiography if margins of cystic lesions are well defined [10]. If the margins are ill-defined, CBCT is a better option for diagnosis. Apart from pre-surgical evaluation of aggressive benign cysts or tumours, CBCT is also helpful in post-surgical follow-up of the margins of lesions that may have a high recurrence rate. A surgeon can find CBCT scans acquired in their own OMS office more convenient and diagnostically sufficient compared to MDCT scans [3].

For surgical planning, a lesion may need to be measured from different angles. For osseous components when compared to the gold standard dry skull, the measurements on CBCT imagines are acceptably accurate with less than 1% error [11, 12].

The treatment options for radicular cyst can be conventional non-surgical root canal therapy when the lesion is localized or surgical treatment like enucleation, marsupialization or decompression when the lesion is large [7]. In this context, specific stomatognathic system homeostasis is achieved by the morphological, biochemichal [13-16] and functional equilibrium between its components due to the specific mechanisms of reaction and adaptation [17, 18].

Experimental part

Material and methods

A total of 10 human dried mandibles with different bone defects miming cysts took part in this study. Each bone defect was made by using a bur with different diameter, which help us to create the bone defects with different volume. In totally, there were 20 bone defects created simulating the bone cyst.

CBCT scans were obtained, from all mandibles and saved in the Digital Imaging and Communications in Medicine (DICOM) format. The equipment used was Planmeca Promax 3D CBCT Mid (*Planmeca OY, Helsinki, Finland*). Scanning was performed by selecting a 100 x 170 mm view field and the following exposure parameters: 90 kV, 12 mA, 13.8 s and 0.4 x 0. 4x 0. 4 mm voxel size.

DICOM files were imported into Romexis 3.0.1 (*Planmeca OY, Helsinki, Finland*), a software able to volume rendering. To achieve the axial, coronal and sagittal sections, the CBCT reconstructions were established with a 1 mm thickness, at a distance of 1 mm.

The bone defects were evaluated separately. The threshold was defined with the Measure Ellipsoid Tool, to include the sinus space and to remove any artefact and background. After threshold selection, a three-dimensional editing was used in order to obtain refined surfaces of the segmentation, resulting in a VOI subsequently rendered into a shaded surface mesh, and each segmented volume (cm^3) was calculated.

Data were analysed by two observers: a general dentist and a maxillofacial surgeon. The accuracy of the two methods in assessing cyst volume was compared. Both have measured the bone defects using Romexis assessed and evaluation according Archimede's principle.

The purpose of this evaluation was to find the easiest and cheapest method in the context in which we use bone grafts and we need to know what amount of material should be purchased and how much does it cost.

The general dentist used the, t-Test, to assess the difference from two methods of examination.

The Archimede's force represents the result (of pressing) of the liquid because of hydrostatic pressure, acts on body submerged in a liquid. The characteristic of the Archimede's force has vertical direction and bottom-up. The force module it is equal with the weight module displaced by the body. The point to be applied of the Archimede's force is called pressure centre if that is homogeneously and completely submerged in liquid.

The general dentist covered the bone defect with footprint Zetta-plus and after I sank the mandible in liquid.

CBCT diagnostic criteria for the differential diagnosis of a cyst were: to be located at the apex of the involved tooth, to be well-defined corticated border, its shape is curved or circular, the internal structure of lesion is radiolucent, the displacement and resorption of the roots of adjacent teeth follow a curved outline, it appears a perforation of cortical plate.

After CBCT analysis we have calculate the real volume of defects fingerprinting the defect with silicone material and immerse the resulting body in the graduated cylinder thus obtaining the standard value at each defect which I compared with the resulting volume at the two examiners. (figs. 1,2,3)

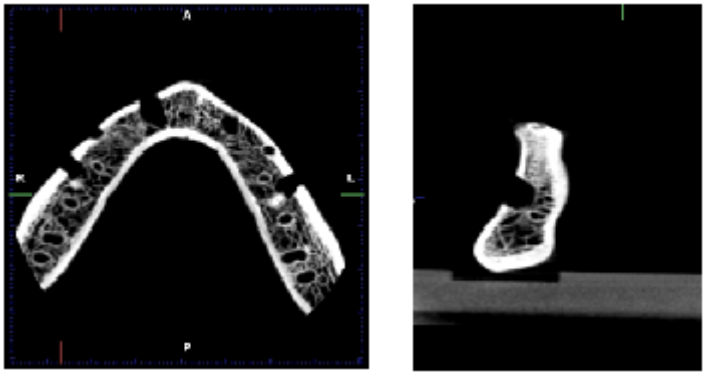

Fig. 1. Axial reconstruct and sagittal reconstructions showing the simulated cystic lesions on dried mandible

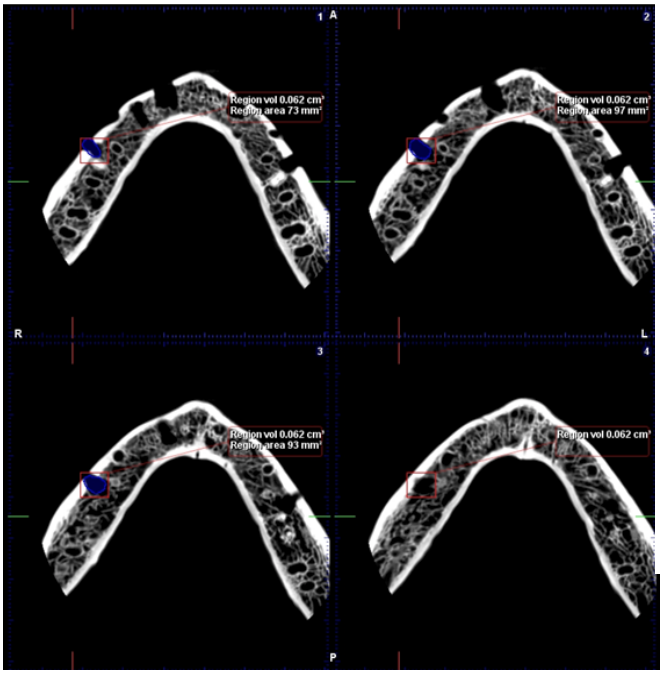

Fig. 2. Axial reconstructions showing the volume analysis of the simulated cystic lesions

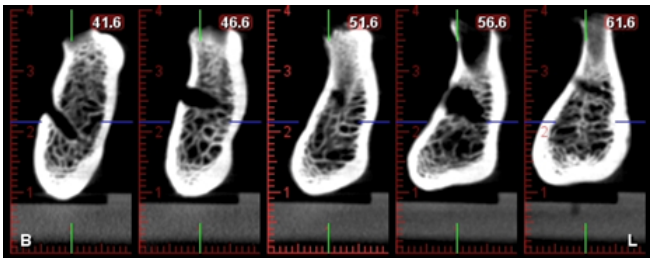

Fig. 3. Paraxial reconstructions showing the simulated cystic lesions

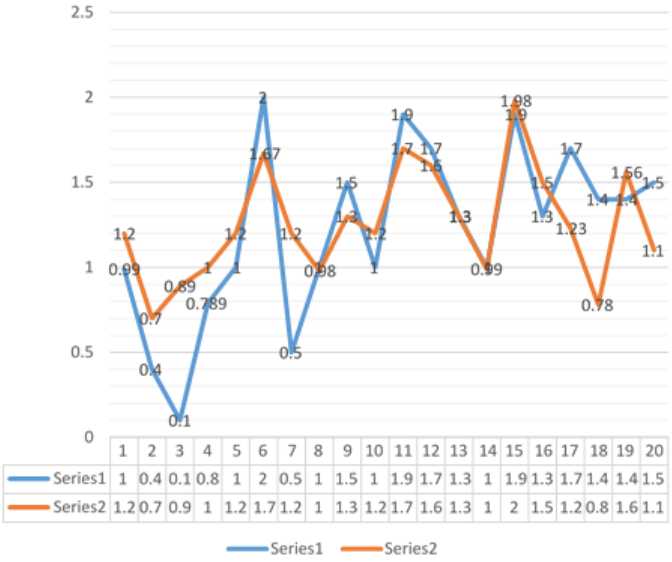

Fig. 4. Scattering data of maxilla facial surgeon

Results and discussions

The bone defects were evaluated separately by the two evaluation methods, Romexis assessed and evaluation according Archimede's principle of the maxillo-facial surgeon (table 1).

The standard deviation is calculated with values: 0.505264235 (resulting from the evaluation of the Romexis data) and 0.32299226 (resulting from the evaluation of the Archimede's principle). The relative degree of scattering is observed. In the case of measurability assessed according to Romexis, the scattering data is bigger 1.21895, the media, in roughly equal environments; data scatter is larger at the string evaluated according to Romexis 1.254. Of these simple calculations, we can draw the conclusion that the accuracy of the measurements is relatively close. In figure 4 Series1- Maxillo-facial surgeon data evaluated according Romexis, and Series2 – maxillo-facial surgeon data evaluated according Archimede's principle (fig. 4, table 2).

Bone defects	Volume (cm^3) Romexis assessed - MAXILLOFACIAL SURGEON-	Evaluated according Archimede's principle (cm^3) - MAXILLOFACIAL SURGEON-
1	0.990	1.20
2	0.400	0.70
3	0.110	0.89
4	0.789	1.00
5	1.000	1.20
6	2.000	1.67
7	0.500	1.20
8	1.000	0.98
9	1.500	1.30
10	1.000	1.20
11	1.900	1.70
12	1.700	1.60
13	1.300	1.30
14	1.000	0.99
15	1.900	1.98
16	1.300	1.50
17	1.700	1.23
18	1.400	0.78
19	1.400	1.56
20	1.500	1.10

Table 1
EVALUATION OF MAXILLO-FACIAL SURGEON

	Column 1	*Column 2*
Column 1	1	
Column 2	0.73645419	1

Table 2
CORRELATION DATA STRINGS

	Variable 1	*Variable 2*
Mean	1.21895	1.254
Variance	0.268728366	0.109815
Observations	20	20
df	19	19
F	2.447106586	
P(F<=f) one-tail	0.029073565	
F Critical one-tail	2.168251601	

Table 3
F-TEST ANT T-TEST APPLIED TO DATA STRINGS
(Were used to confirm the conclusions f-fest (how many dispersions) and t-test (student test) F-test two sample for variances

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	1.05715	1.155
Variance	0.449399082	0.244710526
Observations	20	20
Hypothesized Mea	0	
df	35	
t Stat	-0.525244846	
P(T<=t) one-tail	0.301362397	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	0.602724794	
t Critical two-tail	2.030107928	

Table 4
THE T-TEST: TWO-SAMPLES ASSUMING UNEQUAL VARIANCES

	Variable 1	*Variable 2*	
Mean	1.21895	1.254	
Variance	0.268728366	0.109815	
Observations	20	20	
Pearson Correlation	0.73645419		
Hypothesized Mean Difference	0		
df	19		
t Stat	-0.442434719		
P(T<=t) one-tail	0.331585047		
t Critical one-tail	1.729132812		
P(T<=t) two-tail	**0.663170094**	p>0.05	
t Critical two-tail	2.093024054		

Table 5
THE T-TEST: PAIRED TWO SAMPLE FOR MEANS

The correlation coefficient between the variables is calculated measured in the two measurements. This shows if the measurements, vary together, the resulting value is independent of the unit of measurement used. On each pair of values, the coefficient is 1, which means they are not discrepant, but the two values have the same trend (are close), the bigger difference appears on average, but the value close to 1 is clear that the trend is kept.

Therefore, we can use any of the two types of measurements because the results will be close to each other without any difference affecting the end. And for this method, the environments are approximate equal $p > 0.05$. (tables 3-5).

Data does not show links, are independent/ the values compared do not differ between them,

So we can use any of the methods, there are no significant differences.

The bone defects were evaluated separately by the two evaluation methods, Romexis assessed and evaluation according Archimede's principle of the general dentist (table 6).

In figure 5 Series1-General dentist data evaluated according Romexis, and Series2-general dentist data evaluated according Archimede's principle (fig. 5, table 7).

It is noted that at these measurements, the data shows a small scattering, they being more clustered.

The difference between methods is bigger but not significantly.

The difference between environments is slightly than the case of maxillofacial surgeon. The data obtained by the general dentist by measuring according to Archimede's principle are 13% higher.

At relatively close dispersion on average but comparatively on pairs of values, there are large difference. (table 8)

In both cases performed by the maxillofacial surgeon and those performed by the general dentist can conclude that any of the methods can be used. We used several

Bone defects	Volume (cm^3) romexis assessed - GENERAL DENTIST-	Evaluated according Archimede's principle (cm^3) - GENERAL DENTIST-
1	1.0	1.5
2	1.5	1.3
3	2.0	1.2
4	1.6	1.23
5	1.4	1.45
6	1.9	1.78
7	1.0	0.78
8	1.7	1.34
9	1.8	1.39
10	1.9	1.12
11	1.7	1.9
12	1.9	1.9
13	1.5	1.67
14	1.3	1.0
15	1.89	1.78
16	1.78	1.45
17	1.9	1.11
18	1.7	1.45
19	1.34	1.89
20	1.78	1.5

Table 6
EVALUATION OF GENERAL DENTIST

Fig. 5. Scatering data of general dentist

	Column 1	*Column 2*
Column 1	1	
Column 2	0.253703356	1

Table 7
CORRELATION DATA STRINGS

	Variable 1	*Variable 2*
Mean	1.6295	1.437
Variance	0.087320789	0.099548
Observations	20	20
df	19	19
F	0.877169005	
P(F<=f) one-tail	0.389049323	
F Critical one-tail	0.461201089	

Table 8
THE F-TEST TWO-SAMPLE FOR VARIANCES

	Variable 1	*Variable 2*
Mean	1.6295	1.437
Variance	0.087320789	0.099548
Observations	20	20
Pearson Correlation	0.255705356	
Hypothesized Mean Difference	0	
df	19	
t Stat	2.307515294	
P(T<=t) one-tail	0.01622434	
t Critical one-tail	1.729132812	
P(T<=t) two-tail	0.03244868	
t Critical two-tail	2.093024054	

Table 9
THE T-TEST: PAIRED TWO SAMPLE FOR MEANS

types of comparisons because the amount of data is very small (table 9).

If a multidisciplinary team cannot be used to solve these types of cases, the general dentist can perform the measurements without the error being significant.

The radicular cyst is an odontogenic cyst of inflammatory origin. The radicular cyst is commonly found at apices of involved teeth but can also found on the lateral aspects of roots in relation to the lateral accessory root canals. It has the highest incidence in the 3rd and 4th decade of life with a male predilection. Radicular cysts may occur in all tooth-bearing sites of the jaw but are more frequently seen in the maxillary anterior region than the mandibular region. When infected radicular cysts can enlarge cause bone resorption [7, 20].

Surgical enucleation of a radicular cyst is a common treatment in endodontic practice. The advantage of enucleation is the immediate rehabilitation of the patient, which results in fewer control appointments, which makes it a good choice for patients with poor compliance [7].

The diagnosis and management of endodontic pathologies are dependent on radiography. A 2-dimensional radiography will not be able to represent the 3-dimensional problem. Literature has shown that periapical lesion that are confirmed to the cancellous bone are often missed until they start to erode the cortical plate [21].

The introduction of 3-dimensional imaging has revolutionized dental health care and as a result, the dental profession is experiencing remarkable improvements in the area of diagnostic imagining. CBCT provide a 3-D image, which allows complete visualization of an area in question in axial plane, the sagittal and coronal plane, and it adds depth of field to conventional radiographies. Thus in these cases, use of preoperative CBCT helped in assessing the extent of the cyst, calculate precise the fine alloplastic graft materials which are necessary for the postoperative osseous defect and plan the surgery better than with conventional radiographies.

In the past various root-end, filling materials have been used. Mineral trioxide aggregate (MTA) appears to have become the gold standard for a root-end filling material. MTA is a hydrophilic calcium silicate-based cement that is traditionally used as a root repair material, mainly developed from Portland cement [22, 23]. It consists of tricalcium and dicalcium silicate particles which harden in a wet environment forming calcium silicate hydrate. It proved to be an excellent material for pulp capping, pulpotomy, root perforation repair, root end filling, and pulp regeneration [24, 25]. The success rate for periapical surgery has been reported to be around 84% after 12 month and 92% after 24 month, which is higher than IRM [26]. MTA has been shown to induce hard tissue formation including deposition of cementum [27].

PRF is a second-generation platelet concentrate. There are no artificial biochemical agents, involved in production of PRF, which makes it safe and inexpressive. The physiologic fibrin matrix of PRF obtained as the result of slow polymerization has the ability to hold various growth factors and cytokines and release them at the wound site for a prolonged time [28]. The application of PRF has demonstrated successful and rapid result in terms of bone regeneration. Osseo-graft is believed to act as an osteoconductive and osteoinductive material and as a bone growth promotor. Ahmad et al, Ashish at.al, Sonal et.al, had concluded that combination of growth factors in PRF along with bone graft had increased the bone density in many clinical trials [29, 30].

Conclusions

In the last decade, CBCT has become an important diagnostic tool for oral and maxillofacial surgeons. The benefit of this imaging modality can be better utilized by realizing its capacities and limitations. As the technology now stands, with respect to evaluating maxillofacial disease, CBCT is mostly a tool for diagnosis disease of the osseous structures, currently; it is not useful for the study of lesion limited to soft tissues. Practitioners should exercise caution to avoid over-interpretation of the findings on a CBCT scan. A combination of clinical information, signs, symptoms and radiographic findings should be considered to determine the need for surgery or follow-up examination. On many occasions, follow-up examination can simply be a clinical examination or a single periapical radiography. The practice of oral and maxillofacial surgeons has been more efficient and successful with CBCT and will continue to benefit OMS offices if CBCT is judiciously used based expected diagnostic gain, cost the patient and the radiation dose.

In our study because we don't have a significant difference between Archimede's evaluation and CBCT we can recommend to patients who have a poor status make only radiologic evaluation (ortopantomography) with clinical examination. In mostly cases, our patients came to dental offices to late because they are not educated to visit dentists at 6 month or one year.

In both cases performed by the maxillofacial surgeon and those performed by the general dentist can conclude that any of the methods can be used.

If a multidisciplinary team cannot be used to solve these types of cases, the general dentist can perform the measurements without the error being significant.

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