MODESTUM
OPEN ACCESS

Original Article

Electron J Gen Med 2018;15(3):em16
ISSN:2516-3507
https://doi.org/10.29333/ejgm/85026

A study on the ability of panoramic, CT, Cone-beam CT, MRI and ultrasonography in detecting different foreign-bodies in the maxillofacial region (an in-vitro study)

Hadi Hamidi Shishvan[1], Hamed Ebrahimnejad[2]

ABSTRACT

Background and aim: Entrapment of foreign-bodies is a common phenomenon in traumatic events occurring in the maxillofacial region. The purpose of this study was to evaluate the efficiency of panoramic, CT, Cone-beam CT, MRI and ultrasonography in detecting different foreign-bodies in the maxillofacial region.

Methods: Four different materials were used as foreign-body including metal, glass, rubber and wood. These particles were prepared in four different sizes from 2*2*2 mm to 5*5*5 millimeters. The foreign-bodies were then implanted into a sheep's head in the infraorbital part of maxilla and mandibular buccal region. The panoramic, CT, Cone-beam CT, MRI and ultrasonography were obtained from the model and the images were blindly observed and analyzed by two radiologists. A four-point scale was used to interpret the visibility of found foreign-bodies.

Results: CT had the best efficiency in detecting different foreign-bodies. Cone-Beam CT was the next useful technique. The ability of differentiating the foreign-bodies from the adjacent structures were poor in MRI and ultrasonography. As expected, the panoramic was only efficient in detecting metallic bodies.

Conclusion: CT-scan can be introduced as the best imaging modality in detecting different foreign-bodies especially non-metallic ones. CBCT is also acceptable for metal, glass and rubber particles.

Keywords: cone-beam computed tomography, magnetic resonance imaging, ultrasonography

INTRODUCTION

Entrance of foreign-bodies into the soft-tissues is one of the most common issues in traumatic events occurring at the maxillofacial region. These foreign-bodies are originated from different kinds of materials. Inflammation, infection and pain are the most prevalent outcomes of these events. Accurate localization of a foreign-body helps the surgeon to remove it with minimum adverse effect on the adjacent tissues and reduce the harm to vital organs near the foreign-body (1).

The factors such as size, type and location of foreign-body could make the removal process challenging. Pre-operative radiographic imaging plays an important role in selecting the proper surgical approach (2).

Although metallic foreign-bodies are often detected in radiographs readily, but detection of non-metallic ones requires more comprehensive assessment. The panoramic view, CT, Cone-beam CT (CBCT), MRI and ultrasonography (US) are the most common imaging modalities that are used in maxillofacial foreign-body cases; each has some advantages and disadvantages (3, 6).

The panoramic imaging has limitations in precise localization since it only depicts the foreign-body's adjacent structures in a two-dimensional view. Metallic artefacts could severely reduce the diagnostic efficiency when examining metallic foreign-bodies with CT-scan or MRI. The risk of displacement of metallic bodies limits the usage of MRI in this field. CBCT has also evident shortages in illustrating soft-tissues accurately (7).

[1] *Faculty of Dentistry, AJA University of Medical Sciences, Tehran, Iran*
[2] *Department of Oral & Maxillofacial Radiology, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran*

Correspondence: *Hamed Ebrahimnejad*
Department of Oral & Maxillofacial Radiology, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran

Tel: 00989133983781
E-mail: Hsimple11@yahoo.com

Received: 08 Jan 2017, Accepted: 03 Feb 2017

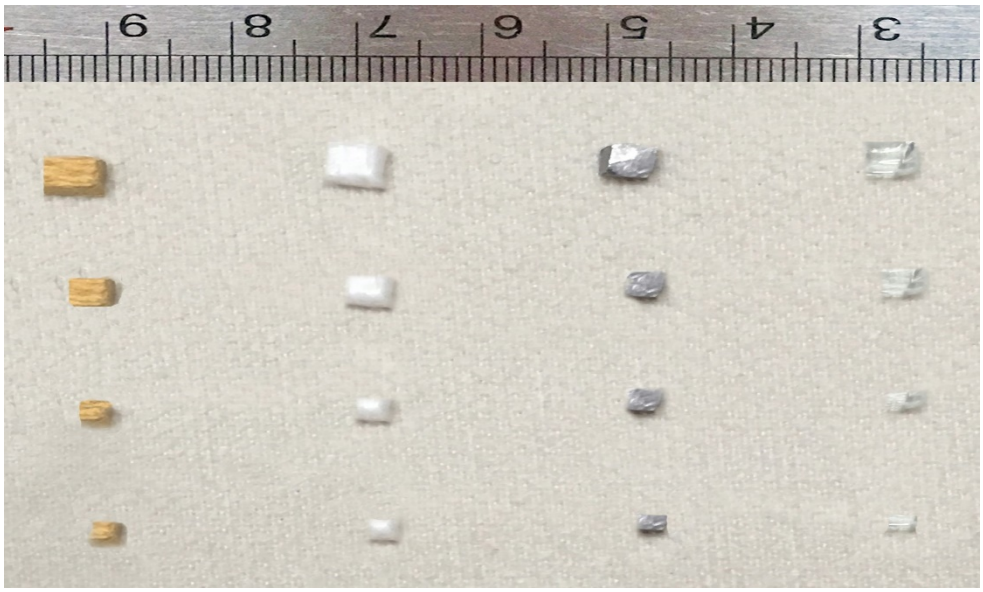

Figure 1: *Different sizes of prepared foreign-bodies*

Figure 2: *Embedding the foreign-bodies in the sheep head*

According to the advantages and disadvantages of each imaging modality, we decided to assess the diagnostic efficiency of panoramic. CT, CBCT, MRI and US in detecting different sizes of foreign-bodies (especially non-metallic ones) in the maxillofacial region.

MATERIALS AND METHODS

In this in-vitro study, we designed and prepared four different materials including metal (steel), glass (car windshield), wood (used in the interior decoration of cars) and condensed rubber (from tires) in 4 different sizes including 2*2*2 mm, 3*3*3mm, 4*4*4 mm and 5*5*5 mm (**Figure 1**).

A sheep's head was used in this study. The whole experiment was done one day after its death and all images were taken on the same day. Foreign-bodies were implanted in the infraorbital and maxillary and mandibular buccal regions on the bone periost using a scalpel and the skin was then sutured (**Figure 2**).

The panoramic radiograph, CBCT, CT-scan, MRI and ultrasonography was acquired from the sheep head.

The panoramic image was obtained with PaX-I (Vatech, South Korea) with the mA=8, kVp=60 and time=10 s. The image was exported from Easydent ver.1.0.1 software (Vatech, South Korea). The MDCT (Sensation 16 Speed 4D, Siemens, Forchheim, Germany) captured the CT images. Since the metallic foreign-bodies caused severe artefacts on CT and MRI images in the pilot study, they were removed before getting CT and MRI images. The CBCT slices were provided by PaX-i3D (Vatech, Korea) with the optimum exposure factors and EzDent3D ver.4.0 software (Vatech, Korea). The MRI scanner

Table 1: *Basic criteria used for image interpretation*

Grade	Assessment	Definition
++++	Excellent image	Excellent resolution of details and excellent visibility, good demarcation from surrounding
+++	Good image	Good resolution of details, demarcation from surrounding, clear visibility
++	Fair image	Insufficient resolution of details, insufficient visibility, insufficient demarcation
+	Bad image	Details not resolved, bad demarcation from surrounding, bad visibility
0	No image	Invisible

Table 2: *The ability of different imaging modalities in detecting metal*

Metal size	OPG	CBCT	Ultrasonography
2*2*2	++++	++++	0
3*3*3	++++	++++	0
4*4*4	++++	++++	+
5*5*5	++++	++++	++

Table 3: *The ability of different imaging modalities in detecting glass*

Glass size	OPG	CBCT	CT	MRI	Ultrasonography
2*2*2	0	++	+++	0	0
3*3*3	0	++	+++	+	0
4*4*4	0	+++	++++	++	0
5*5*5	0	+++	++++	+++	+

Table 4: *The ability of different imaging modalities in detecting rubber*

Rubber size	OPG	CBCT	CT	MRI	Ultrasonography
2*2*2	0	++++	++++	0	0
3*3*3	0	++++	++++	++	0
4*4*4	+	++++	++++	+++	0
5*5*5	+	++++	++++	+++	+

Table 5: *The ability of different imaging modalities in detecting wood*

Wood size	OPG	CBCT	CT	MRI	Ultrasonography
2*2*2	0	0	+	0	0
3*3*3	0	0	++	0	0
4*4*4	0	+	+++	+	0
5*5*5	0	++	+++	+	0

(GE 1.5-T MRI, Healthcare, Milwaukee, WI, USA) created the T1, T2, fat-saturated and FLAIR images. A Honda 2100 (Honda Co., Japan) real-time ultrasound was utilized. The CT, CBCT and MRI coronal slices were used for further assessment.

The obtained images were evaluated on a Lenovo L27q monitor in a normal illumination status by two radiologists. They were unaware of existence of any foreign-body and were asked to record a score for the visibility of possible bodies. A four-point scale was used to interpret the visibility of found foreign-bodies (**Table 1**) (8).

RESULTS

The interobserver agreement kappa coefficient was good between the observers (0.81). The ability of each imaging modality is presented separately (**Tables 2** to **5**) (**Figures 3, 4**).

Panoramic was acceptable for detecting metallic foreign bodies while CBCT performed better on both metallic and non-metallic ones. MRI and ultrasonography could not differentiate well the non-metallic bodies. CT did the best amongst other imaging modalities.

DISCUSSION

Whenever a foreign-body unintentionally enters into the maxillofacial area, it might be located in any region. This study investigated four different types and sizes of foreign-bodies in an in-vitro sheep head model. Various foreign-bodies expose different objective physical characteristics when displayed with different visualization systems. A type of foreign-body could be readily detected on a radiograph while it might be untraceable with another imaging system (9).

In general, choosing the appropriate imaging modality to trace a foreign-body depends on its location, size, physical properties and adjacent structures (10).

Radiologists use different imaging systems like CT, CBCT, MRI, ultrasonography or plain radiology in order to visualize accurately the entrapped foreign-body. CT is suggested as a decent technique for envisioning and localizing foreign bodies since the physician could precisely determine the size and shape of enmeshed material (11). However, metallic

Figure 3: *The panoramic view*

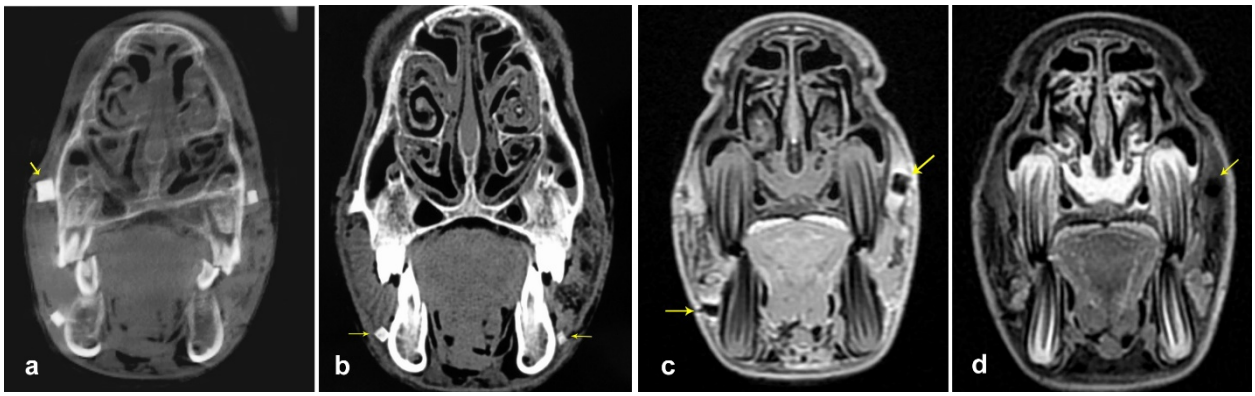

Figure 4: *The CBCT (a), CT (b), MRI-T1 (c) and MRI-T2 (d) images showing rubber foreign bodies (arrows)*

artefacts are troublesome when tracing foreign-bodies with CT scans and could obscure the observer vision. The present survey is consistent with previous studies about the efficiency of CT.

When a foreign-body is located in the superficial tissues, ultrasonography could be a useful technique. On the other hand, it might be inefficient in assessing deep structures or inside the aerated cavities (12). In the current study, ultrasonography were not much successful and was only reliable in large metal foreign bodies' detection.

Although a radiopaque foreign-body is conveniently visualized on even plain radiographs, non-radiopaque ones do no generate a significant image on x-ray images. Therefore, it is the physical properties that arbitrate the visibility of a foreign-body on an image. Hence, a type of foreign-body might be missed with one imaging approach and successfully traced with another one. A foreign body can be revealed on an image when its radiodensity (beam attenuation) vary sufficiently from that of the adjacent structures. However, when the size of foreign body gets smaller, the spatial resolution of imaging system also affects its detection (13-15).

CBCT has the advantage of less metal artefacts and was accredited for localizing foreign bodies in cases studies by Stuehmer et al. Our study, CBCT exhibited well results in detecting all types of foreign bodies except wood (16, 17).

Krimmel studied wooden objects using CT and MRI and found out that CT would be the first diagnostic choice. Wooden foreign bodies were initially missed in plain radiographs and those with longer presence in soft-tissue had higher visibility due to higher density which can be caused by inflammatory reaction around the objects or absorbing water from the surrounding tissues that can increase the radiodensity of wood (18, 19).

According to previous surveys results and our findings, MRI should not be introduced as the first imaging modality for visualizing foreign-bodies because of high metal artefact, risk of foreign-body displacement and being time-consuming. Furthermore, different radiologists might have very different interpretations on MR images (13). The current study demonstrated that MRI could detect glass and rubber but since the most of these materials appear as low-signal or signal-void on MR images, the differentiation of different kinds of foreign-bodies is difficult.

In the current study, CT-scan had the best efficiency in detecting different foreign-bodies. Cone-Beam CT was the next useful technique. The ability of differentiating the foreign-bodies from the adjacent structures were poor in MRI (T1-weighted, T2-weighted, FLAIR and fat-saturated images) and ultrasonography. As expected, the panoramic was only efficient in detecting metallic materials.

Detecting non-metallic non-radiopaque objects might be a challenging issue. CT and CBCT offer hope for illustrating probable non-metallic foreign-bodies in the maxillofacial region.

CONCLUSIONS

CT-scan can be introduced as the best imaging modality in detecting different foreign-bodies especially non-metallic one. CBCT is also acceptable for metal, glass and rubber bodies.

REFERENCES

1. Kaviani F, Rashid RJ, Shahmoradi Z, Gholamian M. Detection of foreign bodies by spiral computed tomography and cone beam computed tomography in maxillofacial regions. J Dent Res Dent Clin Dent Prospects. 2014;8(3):166. http://doi.org/10.5681/joddd.2014.030
2. Hunter TB, Taljanovic MS. Foreign bodies. Radiographics. 2003;23(3):731-57. https://doi.org/10.1148/rg.233025137
3. White SC, Pharoah MJ. Oral Radiology-E-Book: Principles and Interpretation: Elsevier Health Sciences; 2014.
4. Vedaei F, Oghabian M A, Firouznia K, Harirchian M H, Lotfi Y, et al. The Human Olfactory System: Cortical Brain Mapping Using fMRI. Iran J Radiol. 2017;14(2):e16250. https://doi.org/10.5812/iranjradiol.16250
5. Zare Mehrjardi M, Darabi M, Bagheri SM, Kamali K, Bijan B. The role of ultrasound (US) and magnetic resonance imaging (MRI) in penile fracture mapping for modified surgical repair. Int Urol Nephrol. 2017;49(6):937-45. https://doi.org/10.1007/s11255-017-1550-x
6. Haghighi S, Molaei M, Foroughi F, Foroutan M, Dabiri R, Habibi E, et al. Role of endoscopic ultrasound in evaluation of pancreatic neuroendocrine tumors - report of 22 cases from a tertiary center in iran. Asian Pac J Cancer Preven. 2012;13(9):4537-40. https://doi.org/10.7314/APJCP.2012.13.9.4537
7. Gaudino C, Cosgarea R, Heiland S, Csernus R, Zobel BB, Pham M, et al. MR-Imaging of teeth and periodontal apparatus: an experimental study comparing high-resolution MRI with MDCT and CBCT. Eur Radiol. 2011;21(12):2575-83. https://doi.org/10.1007/s00330-011-2209-0
8. Aras M, Miloglu O, Barutcugil C, Kantarci M, Ozcan E, Harorli A. Comparison of the sensitivity for detecting foreign bodies among conventional plain radiography, computed tomography and ultrasonography. Dentomaxillofac Radiol. 2010;39(2):72-8. https://doi.org/10.1259/dmfr/68589458
9. Jarraya M, Hayashi D, de Villiers RV, Roemer FW, Murakami AM, Cossi A, et al. Multimodality imaging of foreign bodies of the musculoskeletal system. Am J Roentgenol. 2014;203(1):W92-W102. https://doi.org/10.2214/AJR.13.11743
10. Lagalla R, Manfre L, Caronia A, Bencivinni F, Duranti C, Ponte F. Plain film, CT and MRI sensibility in the evaluation of intraorbital foreign bodies in an in vitro model of the orbit and in pig eyes. Eur Radiol. 2000;10(8):1338-41. https://doi.org/10.1007/s003309900306
11. Eggers G, Mukhamadiev D, Hassfeld S. Detection of foreign bodies of the head with digital volume tomography. Dentomaxillofac Radiol. 2005;34(2):74-9. https://doi.org/10.1259/dmfr/22475468
12. Orlinsky M, Knittel P, Feit T, Chan L, Mandavia D. The comparative accuracy of radiolucent foreign body detection using ultrasonography. Am J Emerg Med. 2000;18(4):401-3. https://doi.org/10.1053/ajem.2000.7315
13. Oikarinen KS, Nieminen TM, Makarainen H, Pyhtinen J. Visibility of foreign bodies in soft tissue in plain radiographs, computed tomography, magnetic resonance imaging, and ultrasound. An in vitro study. Int J Oral Maxillofac Surg. 1993;22(2):119-24. https://doi.org/10.1016/S0901-5027(05)80818-5
14. Jacobson JA, Powell A, Craig JG, Bouffard JA, Van Holsbeeck M. Wooden foreign bodies in soft tissue: detection at US. Radiology. 1998;206(1):45-8. https://doi.org/10.1148/radiology.206.1.9423650
15. Holmes PJ, Miller JR, Gutta R, Louis PJ. Intraoperative imaging techniques: a guide to retrieval of foreign bodies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;100(5):614-8. https://doi.org/10.1016/j.tripleo.2005.02.072

16. Stuehmer C, Essig H, Bormann K-H, Majdani O, Gellrich N-C, Rücker M. Cone beam CT imaging of airgun injuries to the craniomaxillofacial region. Int J Oral Maxillofac Surg. 2008;37(10):903-6. https://doi.org/10.1016/j.ijom.2008.07.007
17. Zhang Y, Zhang L, Zhu XR, Lee AK, Chambers M, Dong L. Reducing metal artifacts in cone-beam CT images by preprocessing projection data. Int J Radiat Oncol Biol Phys. 2007;67(3):924-32. https://doi.org/10.1016/j.ijrobp.2006.09.045
18. Dalley R. Intraorbital wood foreign bodies on CT: use of wide bone window settings to distinguish wood from air. Am J Roentgenol. 1995;164(2):434-5. https://doi.org/10.2214/ajr.164.2.7839984
19. Krimmel M, Cornelius C, Stojadinovic S, Hoffmann J, Reinert S. Wooden foreign bodies in facial injury: a radiological pitfall. Int J Oral Maxillofac Surg. 2001;30(5):445-7. https://doi.org/10.1054/ijom.2001.0109

◇◈◆◈◇