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Diagnostic Accuracy of Jaw Bone Particles Adjacent to Metallic Foreign Bodies in The Maxillofacial Region: An Animal Model

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Abstract

Introduction: Knowledge of effective imaging methods to determine the metallic foreign bodies is essential to better manage patients with trauma injuries. The study aimed to evaluate of visibility of jaw bone particles adjacent to metallic foreign bodies related to the explosion in the maxillofacial region by panoramic imaging, Computed Tomography (CT), Cone-Beam Computed Tomography (CBCT), and Ultrasonography (US).

Methods: Ten fresh sheep's head was used in this in vitro study. Metal foreign objects with dimensions of 1×10×10 mm, 1×5×5 mm, and 1×3×3 mm were placed in the infraorbital area on the right were used. In each imaging, just one of the iron bodies is applied at the center. Then nine parts of the mandibular bone with dimensions of 1×10×10 mm, 1×5×5 mm, and 1×3×3 mm (3 sets, containing all sizes) were placed 5, 10, 20 mm upper (cephalic), inferior (caudal), and posterior to a metallic foreign body, respectively. The same procedure was repeated for all three sizes of metals. Panoramic imaging, computed tomography, cone-beam computed tomography, and Ultrasonography were obtained by were observed by an oral and maxillofacial radiologist and a general radiologist.

Results: CBCT and CT had good visibility in detections of bone particles adjacent to metallic foreign bodies. There were no significant differences between CBCT and CT regarding detections of bone particles adjacent to metallic foreign bodies (8.56±1.54 and 8.46±2.15 and P=0.56). Panoramic view and US poor visibility in detections of bone particles adjacent to metallic foreign bodies. The mean of number bone detection in the panoramic view was 3.47±1.41 and in the US was 4.06±1.74 (P=0.23). There were significant differences between panoramic view and the US with CBCT and CT regarding detections of bone particles adjacent to metallic foreign bodies (P<0.001). The results were the same regarding distances of bones to metallic foreign bodies.

Conclusion: The results showed that CBCT and CT are effective methods as the first option in detecting bone particles adjacent to metallic foreign bodies in the infraorbital area of the Maxillofacial Region.

Keywords: Maxillofacial, Computed Tomography, Cone-Beam Computed Tomography, and Ultrasonography.

Introduction

Blast injuries to the face can cause functional and aesthetic damage to victims[1]. These injuries cause fractures, crushing, or loss of part or all the bone. In the treatment of these patients, wound debridement from foreign bodies and necrotic tissues should be performed[2]. The healthy bones are then returned to their original location and fixed, and eventually, the lost tissue is rebuilt. Knowledge of effective imaging methods to determine the metallic foreign bodies is essential to better manage patients with trauma injuries[3].

Any object with a foreign source that penetrates the body is known as a foreign body. Trauma is one of the prominent causes of morbidity and mortality among young people in the world[4]. Moreover, trauma injuries such as motor vehicle accidents and gunshots injuries are known as the common causes of traumatic foreign body injuries. In terrorist attacks and war, people are more at risk of foreign body injuries[5].

According to the type of trauma events, the materials, model, and position of the foreign body can change. Foreign bodies in the soft tissues of the maxillofacial region are prevalent such as metal objects, wooden sticks, stone particles, pieces of glass, or sands[6].

Studies reported pain, infection, discomfort, swelling, inflammation, cellulitis, tenderness, and abscess as the main foreign body complications. Also, movement of the foreign body to distant regions and damage to the vessels or nerves is possible complications[7-8].

However, patients with foreign bodies must be funded and treated for any potential complications. Evaluating a specific history, clinical assessment, and imaging are recommended for foreign body detection[9].

Various imaging methods such as panoramic imaging, CBCT, CT, MRI, and ultrasonography have been used for the exposure and localization of foreign bodies. Imaging modalities depend on the type of foreign bodies, injuries, locations of injuries, and cause of injuries can demonstrate different effectiveness to detect foreign bodies. Advanced imaging in different situations can promote the detection of foreign bodies[10-12].

The study aimed to evaluate of visibility of jaw bone particles adjacent to metallic foreign bodies related to the explosion in the maxillofacial region by the panoramic view, CT, CBCT, and the US.

Methods

Ten fresh sheep's head was used in this in vitro study. Iron metal foreign objects and mandibular bone with dimensions of 1×10×10 mm, 1 ×5×5 mm, and 1×3×3 mm were provided to be used in an infraorbital area on the right side (Fig. 1).

Once an iron object with the dimension of 1 ×10×10 mm was placed at the center by 10 mm incision and 10mm depth. Then, nine parts of the mandibular bone with the dimensions of 1×10×10 mm, 1×5×5 mm, and 1×3×3mm (3 sets of each) were placed 5,10,20 mm adjacent to metallic foreign bodies, upper (cephalic) and lower (caudal) and posterior, respectively (Fig. 2).

The same steps were done for 1×5×5 mm, and 1×3×3 mm iron metals at the center for each modality.

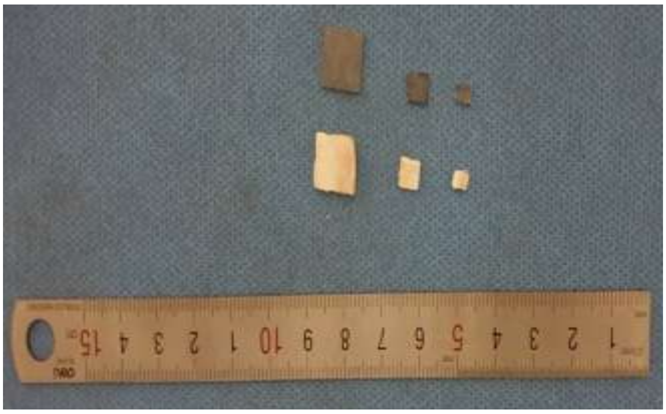

Figure 1: Iron metal foreign objects and mandibular bone with dimensions of 1×10×10 mm, 1 ×5×5 mm, and 1×3×3 mm.

Panoramic (instrumentarium, Germany), CT (Siemens, Germany), CBCT (Planmeca, Finland), and US (GE, USA) were used. Panoramic imaging, computed tomography, cone-beam computed tomography, and Ultrasonography were obtained and observed by an oral and maxillofacial radiologist and a general radiologist.

According to the visibility of the foreign body on each image, a qualitative numerical score includes the good, bad visibility, and invisible. The explanations for these definitions were as good visibility: The metallic foreign and the borders of the iron body were visible. Bad visibility: No details and frames were not visible, invisible: The metallic foreign body was not visible. Also, the count of bones was recorded. USs and CTs were assessed by two general radiologist specialists separately. For determining the validity of observations between them, the Cohen's Kappa coefficient (K) was calculated for the agreement rate; and, for measuring the reliability of observations, all USs and CTs were again observed and scored by each general radiologist specialist two weeks after their primary monitoring, and ICC (Intraclass Correlation Coefficient) was calculated for each. CBCT and Panoramic were assessed by two maxillofacial radiologist specialists, separately; the same processes of validity and reliability measurements for observations of the general radiologist specialists were repeated for the maxillofacial radiologist specialists.

Data were analyzed using SPSS-20 and described by mean, standard deviation, frequency, and percent. Mann- Whitney and Fisher exact tests were used to compare data between groups. A significant level for all tests was considered P-Value less than 0.05.

Figure 2: Nine parts of the mandibular bone with dimensions of 1 ×10×10 mm,1 ×5×5 mm, and 1×3×3 mm (3 sets containing all sizes) were placed 5 mm adjacent to metallic foreign body at the superior, 10mm at the inferior and 20mm at the posterior.

Results

The assessments of each general and maxillofacial radiologist specialist were of high reliability (ICC>0.80). In addition, the assessments between general radiologist specialists (K=0.81) and maxillofacial radiologist specialists (K=0.85) had good validity (the agreement rate between their assessments was high).

CBCT and CT had good visibility in detections of bone particles adjacent to metallic foreign bodies.

There were no significant differences between CBCT and CT regarding detections of bone particles adjacent to metallic foreign bodies (8.56±1.54 and 8.46±2.15 and P=0.56). All 10 cases had good visibility on CT and CBCT; the difference between Panoramic view and US with CT, CBCT was significant (P < 0.001) (Fig. 3 and Table 1).

All 10 cases had poor visibility on US and Panoramic view. Panoramic view and US poor visibility in detections of bone particles adjacent to metallic foreign bodies (Fig. 4). The mean of number bone detection in Panoramic view method was 3.47±1.41 and in US was 4.06±1.74 (P=0.23) (Table 1).

There were significant differences between Panoramic view and US with CBCT and CT regarding detections of bone particles adjacent to metallic foreign bodies (P<0.001).

The results were the same regarding distances of bones to metallic foreign bodies.

Table 1: Assessment of detection of different foreign Bodies and nine part of bone by Panoramic view, CT, CBCT and US

Items	Bones, mean±SD	Metal		
		Good	bad	Invisible
Panoramic view	3.47±1.41	10 (100.0%)	---	---
CT	8.46±2.15	10 (100.0%)	---	---
CBCT	8.56±1.54	10 (100.0%)	---	---
US	4.06±1.74	---	10 (100.0%)	---

All ten iron FBs had poor visibility in US. However, the ten iron samples had good visibility on CT and CBCT. There was no significant difference between Panoramic view, CT, and CBCT (P= 0.86). There was a significant difference between CT, CBCT, and Panoramic view with US (P <0.001) (Fig 5 and 6).

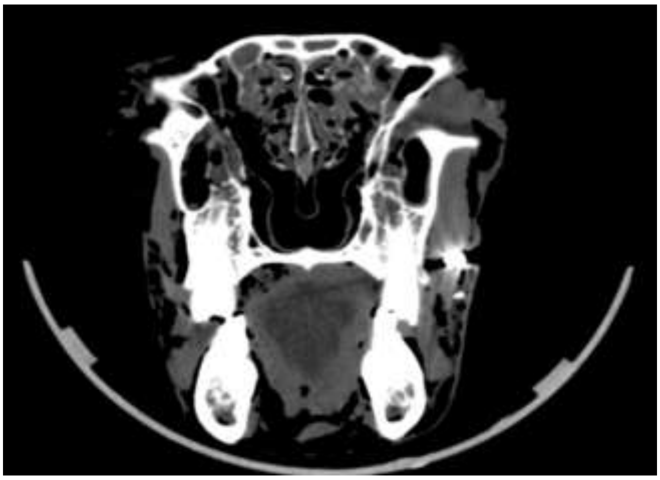

Figure 3: CT scans the head of the sheep. Artifact Due to the metal foreign body makes some limitations in detection of a bone particle but still detectable. In this cut, bone particles and metal objects are visible.

Figure 4: Panoramic view of sheep's head. The metal foreign body is visible, but only three bone particles are visible in this view, especially particles that are not superimposed on jaw bone or teeth.

Figure 5: CBCT view of sheep's head. Bone particles and metal objects are easily detectable. Some metal artifact is present.

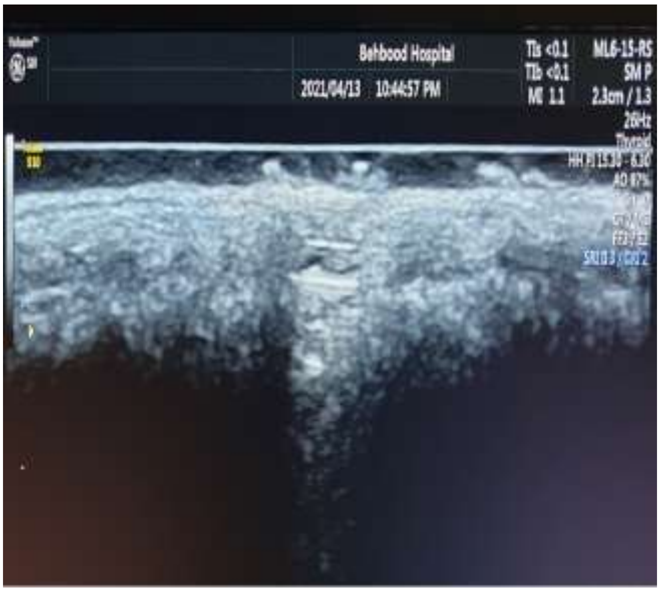

Figure 6: US of the metal foreign body. Two Foreign bodies are detectable in this picture. Emphysema artifacts and distinguishing metal from bone particles make US challenge in the detection of foreign bodies.

Discussion

The accurate locale detection of penetrated foreign bodies is essential for the appropriate treatment of maxillofacial trauma injuries[13]. A suitable imaging modality can improve the quality of detection and the prevention of severe consequences[14-16].

CT was recommended as a conventional method for detection of foreign bodies in the maxillofacial region, as it distinguishes material by measuring HU values, specifically localizes objects, and accurately reconstructs the shape and size of purposes, all of which support the surgical treatment of foreign bodies[17-23].

CT has side effects, including an extreme radiation dose and extensive metal artifacts, which is a particular dilemma when identifying small metal targets[13, 18, 23].

CT can be replaced by CBCT as the initial imaging modality for many 3-dimensional maxillofacial investigations because of its applicability, more moderate radiation dose, a flexible range of landscape, some metal artifacts, and higher accessibility in the dental application. Abdinian et al. (2018) showed CBCT to be the most reliable method for identifying foreign bodies, followed by US and panoramic radiography[14]. Also, Shokri et al. (2017) informed sensitivity rate of CBCT was better than US and MRI methods[25]. Another study in 2016 reported CT, CBCT, US, and MRI for detecting foreign bodies in the maxillofacial area[27] declared US method as the primary choice in the superficial soft tissues, CBCT, and CT was suitable for locating foreign bodies that profoundly entered the tissues or were located under the bone.

Shishvan et al. (2018), in the in vitro study on panoramic radiography, CT, CBCT, MRI, and ultrasonography, showed CT and CBCT as the most effective imaging modality for identifying various foreign bodies in the maxillofacial region[28]. Abdolvardi et al. (2020) showed CBCT as CT can be applied for detecting foreign bodies of various compositions except for plastic particles and sizes in the different maxillofacial areas[17]. In agreement with previous studies in the present study[16, 17, 18]. CT and CBCT for metal were of higher quality to compare US and panoramic view. CBCT and CT have more prominent spatial resolution than other imaging modalities, making them great for visualizing tiny things[27].

The spatial resolution is pointed to the capacity of an imaging system to visualize an object with high distinction and restricted by pixel and voxel size in CT and CBCT methods. Tiny foreign bodies are more suitable to fill pixels or voxels partially, making them less detectable[14, 16].

Kaviani et al. (2014) assessed the diagnostic accuracy of CT and CBCT for the detection of foreign bodies. They revealed that except for wood, all foreign bodies were apparent on both CT and CBCT imaging modalities[28].

US is not suggested to the assess foreign bodies positioned adjacent to hard tissues, such as bone, or within air-filled cavities, such as the nasal cavity and sinuses[17]. Regarding its lower patient radiation dose and cost, CBCT as CT can be used with almost equal accuracy for the foreign bodies detection of different sizes.

Conclusion

The results indicated that CBCT and CT are effective methods as the first option in detecting bone particles adjacent to metallic foreign bodies in the infraorbital area of the Maxillofacial Region.

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None.

Conflict of Interest Disclosures

None

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None

Authors' Contributions

All authors contributed equally in this study.

Ethical Statement

The protocol was confirmed by IR.AJAUMS.REC.1399.082 code in ethical committee of AJA University of Medical Sciences, Tehran, Iran.

References

1. Passali D, Gregori D, Lorenzoni G, Cocca S, Loglisci M, Passali FM, et al. Foreign body injuries in children: a review. Acta Otorhinolaryngol Ital. 2015;35(4):265–71.

2. Hunter TB, Taljanovic MS. Foreign bodies. Radiographics. 2003;23(3):731–57. doi: 10.1148/rg.233025137.

3. 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.

4. Akhaddar A, Abouchadi A, Jidal M, Gazzaz M, Elmostarchid B, Naama O, et al. Metallic foreign body in the sphenoid sinus after ballistic injury: a case report. J Neuroradiol. 2008;35(2):125–8. doi: 10.1016/j.neurad.2007.06.005.]

5. Dort JC, Robertson D. Nonmetallic foreign bodies of the skull base: a diagnostic challenge. J Otolaryngol. 1995;24(1):69–72.

6. Aras MH, 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. doi: 10.1259/dmfr/68589458.

7. Eggers G, Welzel T, Mukhamadiev D, Wortche R, Hassfeld S, Muhling J. X-ray-based volumetric imaging of foreign bodies: a comparison of computed tomography and digital volume tomography. J Oral Maxillofac Surg. 2007;65(9):1880–5. doi: 10.1016/j.joms.2006.09.029.

8. Fowler TR, Crellin SJ, Greenberg MR. Detecting foreign bodies in a head laceration. Case Rep Emerg Med. 2015; 2015:801676. doi: 10.1155/2015/801676.

9. Tas S, Top H. Intraorbital wooden foreign body: clinical analysis of 32 cases, a 10-year experience. Ulus Travma Acil Cerrahi Derg. 2014;20(1):51–5. doi: 10.5505/tjtes.2014.93876.]

10. Shepherd M, Lee J, McGahon MC. Diagnostic Modalities for the Detection of Soft Tissue Foreign Bodies. Adv Emerg Nurs J. 2007;29(4):297–308. doi: 10.1097/01.TME.0000300111.86701.9b.

11. Al-Mujaini A, Al-Senawi R, Ganesh A, Al-Zuhaibi S, Al-Dhuhli H. Intraorbital foreign body: clinical presentation, radiological appearance and management. Sultan Qaboos Univ Med J. 2008;8(1):69–74.

12. Roobottom CA, Weston MJ. The detection of foreign bodies in soft tissue--comparison of conventional and digital radiography. Clin Radiol. 1994;49(5):330–2.

13. Javadrashid R, Golamian M, Shahrzad M, Hajalioghli P, Shahmorady Z, Fouladi DF, Sadrarhami S, Akhoundzadeh L. Visibility of different intraorbital foreign bodies using plain radiography, computed tomography, magnetic resonance imaging, and cone-beam computed tomography: an in vitro study. Canadian Association of Radiologists Journal. 2017 May;68(2):194-201.

14. Abdinian M, Aminian M, Seyyedkhamesi S. Comparison of accuracy between panoramic radiography, cone-beam computed tomography, and ultrasonography in detection of foreign bodies in the maxillofacial region: an in vitro study. Journal of the Korean Association of Oral and Maxillofacial Surgeons. 2018 Feb;44(1):18.

15. Kaviani F, Rashid RJ, Shahmoradi Z, Gholamian M. Detection of foreign bodies by spiral computed tomography and cone beam computed tomography in maxillofacial regions. Journal of dental research, dental clinics, dental prospects. 2014;8(3):166.

16. Shishvan HH, Ebrahimnejad H. 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). Electron J Gen Med. 2018 Jan 1;15: em16.

17. Abolvardi M, Akhlaghian M, Shishvan HH, Dastan F. Detection of different foreign bodies in the maxillofacial region with spiral computed tomography and cone-beam computed tomography: An in vitro study. Imaging Science in Dentistry. 2020 Dec;50(4):291.

18. Shrestha D, Sharma UK, Mohammad R, Dhoju D. The role of ultrasonography in detection and localization of radiolucent foreign body in soft tissues of extremities. JNMA; journal of the Nepal Medical Association. 2009 Jan 1;48(173):5-9.

19. Javadrashid R, Fouladi DF, Golamian M, Hajalioghli P, Daghighi MH, Shahmorady Z, Niknejad MT. Visibility of different foreign bodies in the maxillofacial region using plain radiography, CT, MRI and ultrasonography: an in vitro study. Dentomaxillofacial Radiology. 2015 Apr;44(4):20140229.

20. Krimmel M, Cornelius CP, Stojadinovic S, Hoffmann J, Reinert S. Wooden foreign bodies in facial injury: a radiological pitfall. International journal of oral and maxillofacial surgery. 2001 Oct 1;30(5):445-7.

21. Ober CP, Jones JC, Larson MM, Lanz OI, Werre SR. Comparison of ultrasound, computed tomography, and magnetic resonance imaging in detection of acute wooden foreign bodies in the canine manus. Veterinary Radiology & Ultrasound. 2008 Sep;49(5):411-8.

22. Popescu R, Dobrovăţ B, Nemţoi A, Lăduncă O, Haba D. The importance of CT imaging for detecting traumatic intraorbitar and maxillofacial foreign bodies. Rom Neurosurg. 2011; 18:476–482.

23. Aras MH, 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. Dentomaxillofacial Radiology. 2010 Feb;39(2):72-8.

24. Schnider N, Reichart PA, Bornstein MM. Intraoral foreign bodies detected 40 years after a car accident using cone beam computed tomography. Quintessence International-Journal of Practical Dentistry-English Edition. 2012 Oct 1:741.

25. Shokri A, Jamalpour M, Jafariyeh B, Poorolajal J, Sabet NK. Comparison of ultrasonography, magnetic resonance imaging and cone beam computed tomography for detection of foreign bodies in maxillofacial region. Journal of clinical and diagnostic research: JCDR. 2017 Apr;11(4):TC15.

26. Valizadeh S, Pouraliakbar H, Kiani L, Safi Y, Alibakhshi L. Evaluation of visibility of foreign bodies in the maxillofacial region: comparison of computed tomography, cone beam computed tomography, ultrasound and magnetic resonance imaging. Iranian Journal of Radiology. 2016 Oct;13(4).

27. Javadrashid R, Fouladi DF, Golamian M, Hajalioghli P, Daghighi MH, Shahmorady Z, Niknejad MT. Visibility of different foreign bodies in the maxillofacial region using plain radiography, CT, MRI and ultrasonography: an in vitro study. Dentomaxillofacial Radiology. 2015 Apr;44(4):20140229.

28. Kaviani F, Javad Rashid R, 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):166–71.