COMPARISON OF CONE-BEAM COMPUTED TOMOGRAPHY AND PANORAMIC RADIOGRAPHY IN DETECTING MAXILLARY SINUS SEPTA

Maksiller Sinüs Septasının Belirlenmesinde Konik Işınlı Bilgisayarlı Tomografi ve Panoramik Radyografinin Karşılaştırılması

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ABSTRACT

Purpose: The purpose of this retrospective study was to compare the performance of cone-beam computed tomography (CBCT) and panoramic radiography in detecting the presence and location of maxillary sinus septa.

Materials and methods: This study included radiographic examination of 104 maxillary sinuses of 52 individuals (26 females, 50% and 26 males, 50%) whose panoramic radiographs and CBCT images were obtained for several dental causes which were examined by the consensus of four dentomaxillofacial radiologists. The posterior maxillary segments in proximity of maxillary sinus were classified as edentulous and dentate maxillary segments. The location of maxillary sinus septa was classified as primary septa and secondary septa according to the presence of maxillary tooth at the affected site. The maxillary sinus septa were divided into three categories (anterior, middle and posterior) according to its relation with posterior maxillary teeth. Data were statistically analyzed with chi-square and Fisher’s exact tests.

Results: The septa were found in 23.1% and 29.8% of the maxillary sinuses on panoramic radiography and CBCT images, respectively. The majority of maxillary sinus septa were observed in dentate posterior maxillary segments on both panoramic (45.8%) and CBCT (64.5%) images. Statistically significant differences (p<0.001) were found between panoramic radiography and CBCT images for presence, location and neighborhood with the posterior maxillary teeth of maxillary sinus septa.

Conclusion: The results of this study demonstrated the low reliability of panoramic radiography images in the detection of maxillary sinus septa. CBCT images can provide valuable information to the clinicians about the presence and location of maxillary sinus septa.

Keywords: Maxillary sinus septa; panoramic radiography; cone-beam computed tomography

ÖZ

Amaç: Bu retrospektif çalışmanın amacı, maksiller sinüs septasının varlığını ve konumunu belirlemede konik-ışınlı bilgisayarlı tomografi (KIBT) ve panoramik radyografi yöntemlerinin karşılaştırılmasıdır.

Gereç ve yöntem: Bu çalışmada 52 kişiden çeşitli dental nedenlerle elde edilmiş panoramik radyografi ve KIBT görüntülerindeki 104 maksiller sinüs, dört ağız, diş ve çene radyolojisi uzmanının fikir birliği ile incelendi. Maksiller sinüsle yakın komşulukta posterior maksiller boğnez, dişsiz ve dişli olarak sınıflandırıldı. Maksiller sinus septasının yeri, ilgili bölgesindeki maksiller boğne diş varlığına göre ön, orta ve arka olarak üç kategoriye ayrıldı. Veriler chi-square ve Fisher’in kesin testi ile istatistiksel olarak analiz edildi.

Bulgular: Panoramik radyografi ve KIBT görüntülerindeki maksiller sinüslerin sırasıyla, %23.1 ve %29.8’inde septa bulundu. Hem panoramik radyografi (%45.8) hem de KIBT görüntülerindeki (%64.5) maksiller sinüs septasi çoğunlukla, dişli posterior maksiller bölgesinde izlendi. Maksiller sinüs septasının varlığı, lokalizasyonu ve posterior maksiller dişlerle olan komşulüğa için panoramik radyografi ve KIBT görüntüleri arasında istatistiksel olarak anlamlı fark (p<0.001) bulundu.

Sonuç: Çalışmanın sonuçları, maksiller sinüs septasının belirlenmesinde panoramik radyografi görüntülerinin güvenilirliğinin dışمنذ olduğunu gösterdi. KIBT görüntüleri ise maksiller sinüs septasının varlığını ve konumu hakkında klinisyenlere yararlı bilgi verebilir.

Anahtar kelimeler: Maksiller sinüs septa; panoramik radyografi; konik-ışınlı bilgisayarlı tomografi

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Introduction

The maxillary sinuses, which occupy the body of the maxilla generally as large pyramidal cavities, have variable morphologies and sizes. They are the largest of the paranasal sinuses. (1, 2) Maxillary sinus is in close proximity to the orbit, alveolar ridge and maxillary posterior teeth, thus, this anatomical region may sustain injuries during dental procedures. The maxillary sinus elevation technique is one of the most commonly used strategies for dental implant rehabilitation in atrophic posterior maxilla (3-5). Since the maxillary alveolar process forms the maxillary sinus floor, assessment of possible alterations in maxillary sinuses is essential especially in the preoperative implant planning in the maxillary posterior region (6). In the images of the maxillary sinuses, one or multiple transvers radiopaque lines, which are named ‘septa’ can be observed. They were originally described in 1910 by Underwood (7). They can divide maxillary sinus into two or more cavities. As Zijderveld et al. (5) and Boyne and James (3) stated the presence, location, shape, number and size of septa in the maxillary sinus, especially the inferior wall, increase the risk of sinus membrane perforation during sinus floor elevation procedures (8-12). There are several hypotheses suggested by different authors concerning the presence of antral septa (10, 13-16). Krennmair et al. (14) have classified the septa into primary and secondary septa. Primary septa is thought to arise during maxillary development whereas secondary septa arises from the irregular pneumatization of the sinus floor following tooth loss. In previous studies the septae were accepted as the wall of the cortical bone at least 2.5 mm in height within the maxillary sinus (9, 13, 17).

Accurate radiographic identification of these structures is necessary to obtain detailed information regarding maxillary sinus anatomy during maxillofacial surgery. Dental panoramic radiography, computed tomography (CT) and cone-beam computed tomography (CBCT) have been used to identify the maxillary sinus septa (9, 10, 18). CBCT is recommended as an excellent, low cost technique for the evaluation of maxillary sinus septa with only slightly more ionizing radiation dose than panoramic radiography and far less than CT (19-23). Although various studies compared panoramic radiography and CT for detection of maxillary sinus septa, no study was conducted regarding the comparison of panoramic radiography and CBCT (6, 22, 24).

The purpose of this retrospective study was to compare the performance of CBCT and panoramic radiography in determining the presence and location of maxillary sinus septa.

Materials and Methods

Sample characteristics and imaging protocols

This study included panoramic radiographs and CBCT scans of 104 maxillary sinuses in 52 individuals (26 females, 26 males), obtained for several dental causes which were available in the database of a private imaging center. Before any radiographic images were obtained, the patients were asked to sign informed consents for radiography and clinical examinations according to the principles of the Helsinki Declaration. Only researchers had access the acquired data. Panoramic images used in the study had been obtained using Planmeca Proline XC (Planmeca, Helsinki, Finland) unit, a charge coupling device (CCD) based digital panoramic unit operating at 60-80 kVp and 4-12 mA, with a 0.5 mm focal spot and an exposure time of 16 seconds. CBCT images were acquired with Iluma Ultra Cone-beam CT Scanner (3M Inttec, Ardmore, OK, USA) with a 24.4×19.5 cm amorphous silicon flat-panel image detector and a cylindrical volume of reconstruction up to 21.2×14.2 cm. CBCT images were obtained at 120 kVp, 1-3.8 mA with 0.2 mm voxel size, an exposure time of 7.8 seconds and a field of view of 8 cm.

Study variables

The posterior maxillary segments in proximity of maxillary sinus were classified as edentulous (partial, complete and atrophic edentulous) and dentate maxillary segments (14). The location of maxillary sinus septa was classified as primary septa if it was located from a maxillary tooth root; and secondary septa located superior to an edentulous ridge (3, 10, 14, 22). The maxillary sinus septa according to neighborhood with the posterior maxillary teeth was divided into three categories: anterior region, between the mesial and distal aspects of the second premolar root; middle between distal aspects of second premolar and second molar; and posterior, distal aspect of the root of the second molar (6, 9, 17). In this study, septa of at least 2.5 mm in height were evaluated in accordance with previous studies (9, 13, 17).
Detection of maxillary sinus septa

Radiographic examination protocol

The examinations were carried out by the agreement of four dentomaxillofacial radiologists (M.A, I.P, I.C and E.S) with at least five years of experience on panoramic images and axial, coronal and sagittal sections for CBCT examinations, on the computer monitor (21 inch LCD monitor with 1280 × 1024 resolution) in a quiet room with subdued ambient lighting. Totally 11 sessions were arranged in a period of two weeks and 10 maxillary sinuses were evaluated in each session, eventually the examinations were completed in 22 weeks. The examples of maxillary sinus septa were presented in Figure 1 and 2.

Statistical analysis.

Data were statistically analyzed by using SPSS-15.0 version (SPSS Inc, Chicago, IL, USA) for Windows with descriptive statistics, chi-square and Fisher’s exact tests. Confidence interval was set to 95% and p-values less than 0.05 were considered statistically significant.

Figure 1. An example of maxillary sinus septa on panoramic (A) and CBCT (B,C and D) images.

Figure 2. An example of maxillary sinus septa on panoramic (A) and CBCT (B,C and D) images.
Results

In total, 104 maxillary sinuses of 52 individuals between 16 and 75 years of age (mean±standard deviation (SD): 46.8±15.9 years) were examined in this study. There were two age groups; 26 subjects’ ages were under 50. Regarding the posterior maxillary segments in proximity of maxillary sinus; the most common posterior maxillary segments were partial edentulous (n=22, 42%), followed by dentate (n=15, 29%), atrophic edentulous (n=11, 21%) and complete edentulous jaws (n=4, 8%) in the right quadrants, respectively. In the left quadrants, dentate posterior maxillary segments (n=20, 38%) were mostly observed, followed by partial edentulous (n=15, 29%), atrophic edentulous (n=12, 23%) and complete edentulous jaws (n=5, 10%). The prevalence of maxillary sinus septa was found to be 23.1% (n=24) and 29.8% (n=31) on panoramic and on CBCT images, respectively. 24 maxillary sinus septa were observed in 21 patients on panoramic images and 31 maxillary sinus septa were observed in 20 patients on CBCT images whose mean age±SD was 39.05±16.6 years. Most of the septa was observed in subjects under age 50. Thus, bilateral maxillary sinus septa was determined in 3 (5.8%) patients on panoramic images and in 8 (15.4%) patients on CBCT images and also double unilateral septa was observed in 3 (5.8%) patients on CBCT images. The majority of maxillary sinus septa was observed in dentate posterior maxillary segments which was followed by partial edentulous, atrophic edentulous and complete edentulous jaws on both panoramic and CBCT images (Table 1).

Table 1. The distribution of maxillary sinus septa according to the adjacent posterior maxillary segments.

| Posterior maxillary segments | Presence of maxillary sinus septa |
|------------------------------|----------------------------------|
|                              | Panoramic images | CBCT images |
|                              | n (%)            | n (%)       |
| Partial edentulous           | 8 (33.3)         | 6 (19.4)    |
| Complete edentulous          | 2 (8.3)          | 2 (6.4)     |
| Atrophic edentulous          | 3 (12.5)         | 3 (9.7)     |
| Dentate                      | 11 (45.8)        | 20 (64.5)   |
| Total                        | 34 (100)         | 31 (100)    |

Regarding the location of maxillary sinus septa; the frequencies of primary septa was 58.3% (n=14) and 58.1% (n=18) on panoramic and CBCT images, respectively. The frequencies of secondary septa were found to be 41.7% (n=10) and 41.9% (n=13) on panoramic and CBCT images, respectively. Statistically significant difference (p<0.001) was observed between panoramic radiography and CBCT scans for the location of maxillary sinus septa (Table 2). Regarding presence of the maxillary sinus septa and its neighborhood with the posterior maxillary teeth; the majority of maxillary sinus septa were observed at the anterior region on panoramic images (Table 3). However, the maxillary sinus septa was mostly observed at the middle region on CBCT images. Statistically significant differences (p<0.001) were found between panoramic radiography and CBCT scans for the presence and neighborhood with the posterior maxillary teeth of the maxillary sinus septa (Table 3).

Table 2. The results of statistical analysis for the location of maxillary sinus septa.

| Location of maxillary sinus septa | Panoramic images | CBCT images | p value |
|-----------------------------------|------------------|-------------|---------|
|                                   | n (%)            | n (%)       |         |
| Primary                           | 14 (58)          | 18 (58)     |         |
| Secondary                         | 10 (42)          | 13 (42)     | p<0.001*|
| Total                             | 24 (100)         | 31 (100)    |         |

*Fisher’s Exact Test
Detection of maxillary sinus septa

In a systematic review, the prevalence of maxillary sinus septa ranged between 14.3% and 33.3% in different countries (29-34). However, it was reported as 20.6% and 58% by CBCT in previous studies. The prevalence of maxillary sinus septa has been detected using panoramic images (25-28). Our software analyses for septa detection. Several studies compared panoramic radiography with CT images. Velasquez-Plata et al. (27) and Kim et al. (9) used software analyses for septa detection. Several studies detected septa using panoramic images (25-28). Our study represents the first performance for comparison of the CBCT and panoramic radiography findings in detecting the presence, number and location of maxillary sinus septa. We examined 104 maxillary sinuses of 52 individuals on both digital panoramic and CBCT images. The prevalence of maxillary sinus septa has been reported as 20.6% and 58% by CBCT in previous studies performed in different countries (29-34). However, it was reported that the prevalence of maxillary sinus septa ranged between 14.3% and 33.3% in a systematic review.

Table 3. The distribution and statistical analysis for the presence and neighborhood with the posterior maxillary teeth of the maxillary sinus septa.

| Presence and neighborhood with the posterior maxillary teeth of septa | Panoramic radiography findings |
|---------------------------------------------------------------|------------------------------|
|                                                               | Absent | Anterior region | Middle region | Posterior region | Total | p value |
| Anterior region n | 1 | 1 | 0 | 0 | 2 | |
| % | 3.25% | 3.25% | 0% | 0% | 6.5% | |
| Middle region n | 8 | 9 | 6 | 0 | 23 | |
| % | 25.85% | 29% | 19.35% | 0% | 74.2% | p<0.001* |
| Posterior region n | 5 | 0 | 0 | 1 | 6 | |
| % | 16.1% | 0% | 0% | 3.25% | 19.35% | |
| Total n | 14 | 10 | 6 | 1 | 31 | |
| % | 45.2% | 32.25% | 19.35% | 3.25% | 100 | |

Fisher’s Exact Test

Discussion

Accurate diagnosis of maxillary sinus septa is possible with radiographic identification. Panoramic radiography, CT and CBCT have been used to identify the maxillary sinus septa. However, exact and definitive assessment can be achieved by CT and CBCT scans. CBCT is recommended as an excellent, low cost technique for the evaluation of maxillary sinus septa with only slightly more radiation dose than panoramic radiography and far less than CT (22, 25). Although various studies compared panoramic radiography with CT for the detection of maxillary sinus septa, according to our knowledge, no study was conducted regarding the comparison of panoramic radiography and CBCT (6, 25, 26).

Different observation methods have been used by several authors. Underwood (7) examined 45 dried skulls, Ulm et al. (17) observed maxillary sinuses during sinus lift procedures, Lugmayr et al. (15) observed sinus septa on CT images. Krennmair et al. (14) assessed prevalence of septa on CT images and 24.5% of the sinuses were also observed during sinus lifting. Kasabah et al. (13) compared panoramic radiography by CT images. Velasquez-Plata et al. (27) and Kim et al. (9) used software analyses for septa detection. Several studies detected septa using panoramic images (25-28). Our study represents the first performance for comparison of the CBCT and panoramic radiography findings in detecting the presence, number and location of maxillary sinus septa. We examined 104 maxillary sinuses of 52 individuals on both digital panoramic and CBCT images. The prevalence of maxillary sinus septa has been reported as 20.6% and 58% by CBCT in previous studies performed in different countries (29-34). However, it was reported that the prevalence of maxillary sinus septa ranged between 14.3% and 33.3% in a systematic review in French population (30). Jang et al. (31) examined 151 patients and reported its prevalence of 26% in Korean population. Li et al. (32) analyzed 424 patients in Han population and observed the maxillary sinus septa in 44.8% of the patients. Dobele et al. (33) determined the maxillary sinus septa in 20.6% of the Latvian patients. Lana et al. (34) reported the prevalence of maxillary sinus septa as 44.4% in Brazilian patients. The prevalence of maxillary sinus septa has been reported as 58% in Turkish patients by Orhan et al. (23). In the current study, prevalence of maxillary sinus septa was found to be 23.1% and 29.8% on panoramic and on CBCT images. Although, this result was lower than the previous study performed in Turkish population, it was in accordance with some previous reports. Orhan et al. (23) reported that unilateral sepsa has been determined in majority of cases with mixed dentition (3.2%) and bilateral septa has been determined in majority of cases with dentition (23%). Unilateral and bilateral two septa were found in 1.08% and 0.2% of the cases, respectively. Also, unilateral and bilateral three septa were found in 0.4% of the cases by the same authors. In the present study, the frequency of unilateral maxillary sinus septa was higher (40.4%) than bilateral septa (5.8%) and also unilateral double sepsa was observed in 5.8% of the patients on CBCT images. This result is different from Orhan et al.’s (23) results. Some authors (23, 35) observed higher prevalence of septa in partially edentulous maxilla than in totally edentulous ones and reported no statistically significant differences between the different types of edentulism. However, other authors (9, 14, 36, 37) reported a higher prevalence of septa in completely edentulous patients than in partially edentulous patients. In the present study, the majority of maxillary sinus septa was observed in dentate posterior maxillary segments which was followed by partial edentulous, atrophic edentulous and complete edentulous jaws on both panoramic and CBCT images,
which is different from previous studies. Location of the maxillary sinus septa was determined by different authors. Underwood (7) reported most of the septa has been found in the posterior region over third molar roots; Ulm et al. (17) reported a greater frequency of septa in the anterior region, as did Krennmair et al. (14) (70% of septa in the premolar region); and Velásquez-Plata et al. (27), Kim et al. (9), González-Santana et al. (25), Orhan et al. (23) found the highest frequency in the middle region, as 41%, 50.8%, 65% and 69.1%, respectively. However, Jang et al. (30) reported the highest frequency they have observed was in the middle and anterior regions for edentulous and dentate patients, respectively. In the present study, the highest prevalence was found in the anterior region as 32.2% on panoramic images and 74.2% were observed in the middle region on CBCT images which is in accordance with previous reports. Krennmair et al (14) reported the rate of false diagnosis on panoramic radiographs as 21.3% while Kasabah et al. (13) reported as 44.1% and Gonzalez-Santana et al. (25) as 11.8%. We also found statistically significant differences between panoramic radiography and CBCT scans for the detection of septa presence, location and distribution of primary/secondary septa in accordance with previous studies.

Conclusion

The results of this study demonstrated that there are significant differences between panoramic radiographs and CBCT images in the detection of presence, number and location of maxillary sinus septa. CBCT is a useful imaging method to determine of maxillary sinus septa as it provides cross-sectional images.

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None declared

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