Assessment of Cone-Beam Computed Tomography (CBCT) Findings in Facial Asymmetric Patients

Original Article

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Abstract

Introduction: Due to the complexity of facial asymmetry, the diagnosis of different aspects of asymmetry via conventional radiographs is not precise. In this study, we investigated findings of facial asymmetry by using cone- beam computed tomography (CBCT) images.

Materials and Methods: In this descriptive study, we evaluated CBCT findings of 18 patients i.e. a group of 14 females and 4 males having a mean age of 22.7 years who referred to a maxillofacial radiology clinic due to facial asymmetry from 2010 to 2011. Findings of asymmetry were investigated using axial, coronal and sagittal views.

Results: As detected in axial view, 9 of 18 patients had yaw in the maxilla. Approximately 14 and 11 patients had yaw in the mandible and zygoma respectively. Differences were observed between the medio-lateral dimensions of the condylar heads in 7 patients. We also detected the cervical spine deviation in 9 cases. Moreover, a difference in the antero-posterior position of the glenoid fossa in 10 patients was observed. In coronal view, “roll” i.e “cant” in the maxilla, mandible and orbital cavities was found in 14, 12 and 1 patient respectively. Differences in the condylar neck height in 9 patients and in the level of the glenoid fossa in 11 patients were observed.

Conclusion: CBCT is effective in evaluating the details of asymmetry and its effects on facial structures. In addition, three-dimensional approaches for the analysis of asymmetry transform it from a simple and predictable phenomenon into an incredibly complicated process. Pursuing orthodontic treatment plan without considering these complexities and details is not successful.

Key words: • Cone- beam computed tomography •Facial asymmetry •Findings

Introduction

Asymmetry is created by the unequal growth of facial structures rather than the facial midline. Usually the human face is not completely symmetrical resulting in a form of asymmetry that is slight and not always visible.(1)

Generally, facial asymmetry affects the middle- and upper-third of the face. Upper face asymmetry is detected in only 5% of subjects whereas 36% of subjects have asymmetry in the middle-third that usually affects the nasal bone, but sometimes it is effective on zygomatic bones, too. Seventy percent of asymmetric patients have a deviation in their chin. Approximately one-half of patients with middle and upper-third asymmetry also have mandibular asymmetry. Twenty-eight percent of skeletal Class II (CLII) patients have asymmetry that is significant unlike the other skeletal subgroups.(2)

Esthetic and social features of asymmetry as well as their related functional and medical aspects must be considered when we discuss this topic.(3)

Treatment of asymmetry is better performed in its primary stages when there is growth tendency. Otherwise, treatment can be a difficult process and it can result in having to perform an advanced and complicated surgery. In the diagnosis and treatment of asymmetry, the emphasis is on the study of all facial structures rather than on the evaluation of the profile; thus, exact clinical examination of facial proportions is necessary.(2)

Surgical correction is indicated in the majority of facial asymmetry cases. This is usually accompanied by reconstructing the deformed portion while considering the normal opposite side as a reference. Although the treatment looks quite easy, due to the complexity in the identification and assessment of the degree of deformity, the treatment results are consequently somewhat unpredictable and sometimes less than optimal.(3)

Panoramic view, lateral and posterioranterior(PA) cephalograms are used commonly as the primary radiographic methods to analyze craniofacial bone morphology.(4)

Cephalometric analysis is the most relevant and common tool in orthodontics due to its validity and practicability for assessing of craniofacial complex growth changes and determination of an orthodontic or ortho-surgical treatment plan.(5)

Errors in patient positioning, different magnification of bilateral structures, superimposition of craniofacial structures and difficulty in determining the precise localization of cephalometric landmarks are the common problems associated with conventional cephalograms.

Currently, computed tomography (CT) scans are widely used to gain threedimensional information from the craniofacial complex. In spite of its benefits, clinicians are cautious about using conventional CT because a long procedure is conducted in a closed space and the patient is exposed to a high level of radiation.(6)

In recent decades, cone-beam computed tomography (CBCT) has been developed for head and neck imaging and it is also suitable for craniofacial imaging. CBCT scanners can provide complete volumetric data. These scanners use cone- or pyramid-shaped geometry of the x-ray beam, which permits a more efficient utilization of x-ray photons rather than the thin fan-shaped geometries that are characteristic of many medical CT devices.(7)

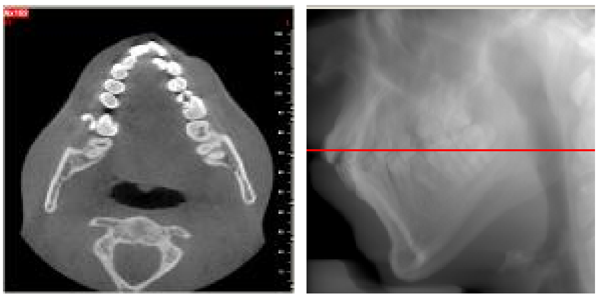
By considering this matter and by making a more precise diagnosis of an asymmetrical structure, the dentist can correctly select the proper orthopedic or orthodontic treatment. Therefore, the assessment of craniofacial structures as a unique complex affecting each other in three-dimensional form and from different aspects during the growth process is necessary. This aim is achievable by using CBCT technology because CBCT, in addition to generating high quality images, decreases the cost and radiation dose more than conventional CT.(7,9) Thus, in this investigation we tried to focus on different findings of facial asymmetry and whether they occurred concurrently as detected by CBCT technology.

Materials and Methods

In this descriptive study, CBCT findings of 18 asymmetric patients including 14 women and 4 men with the mean age of 22.72 years who referred to a private maxillofacial radiology clinic (Rasht, Iran) between July and September of 2011, were evaluated.

All images were taken by New Tom VG (QR SRL, Italy) device in full mode (9-inch) field of view and 0.25-0.3 mm voxel size. Exposure parameters were regulated for each patient automatically. In prepration of CBCT images, an important point was that the patient's head not be twisted or tilted. The position of the patient's head was checked based on lateral and posterior-anterior scout images taken during the process of CBCT image acquisition.

Axial images with a 1mm thickness and interval along with coronal and sagittal images having a 1mm thickness and a 2mm interval and 3D images were reconstructed from volumetric data. In axial images, we focused on different variables such as the presence or absence of yaw (a twist of the mandible, maxilla and zygoma in relation to a horizontal plane), differences in the thickness of the zygomatic bone, discrepancies in the anterior-posterior dimension of the orbits, dissimilarities in the shape and anatomical form of the optic canal, differences in the medio-lateral dimensions of condylar heads, the position of the cervical spine and the hyoid bone related to the midline as well as symmetry of the nasopharyngeal passage (Figure 1).



(a) (b)

Figure 1. (a) & (b) Yaw in the mandible and deviation of the cervical spine in axial view

We examined coronal images to determine the presence or absence of "roll or cant" (differences in the level of the right and the left mandibular and/or maxillary plan in the vertical plane), differences in the level of the orbital floor on the right and left sides, discrepancies in the palatal depth of the right and left sides, dissimilarities in the height of the condylar neck as well as differences in the level of the glenoid fossa (Figure 2). These remarkable data were considered after a pilot study was made using CBCT images of 6 patients. Sagittal and 3D images were used to confirm or validate several unclear findings seen in coronal or axial slices. Finally, we assessed the above-mentioned items both separately and concurrently with each other.

Results

In this study, 10 findings in axial views and 4 findings in the coronal views were evaluated. The results of these assessments are noted in Tables 1 and 2.

Axial view

Nine of 18 patients had yaw in maxilla. Yaw in the mandible and zygoma were observed in 14 and 11 patients. Yaw on the left side in the maxilla, mandible and zygoma were found in 7, 10 and 9 patients respectively.

In 8 patients, yaw was seen in the maxilla and mandible simultaneously. In 6 of 8 patients, yaw occurred in the mandible and maxilla toward the same side. In 8 patients, yaw was found in the maxilla and zygoma, simultaneously. In these 8 patients, the direction of yaw in the maxilla and zygoma was similar. In addition, 8 of 18 patients had yaw in all three structures and 6 of these 8 revealed a similar direction of yaw.

In 4 patients, discrepancies were detected between the size of right and left zygomatic bone thickness. In all of them, the left zygomatic bone was thicker than that of the right side. Differences in the size of the right and left sinuses were observed in 9 patients. In 6 patients, the left maxillary sinus was larger.

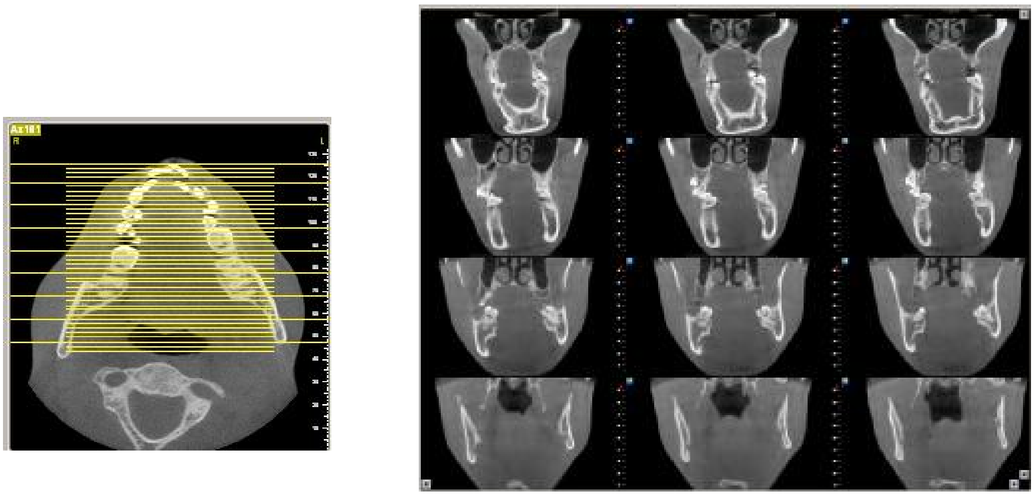
Differences in the medio-lateral size of the orbit in central cuts and in the anatomical shape or form of the optical canal were not observed in any of the patients.

Differences in the biggest medio-lateral dimensions of condylar heads were observed in 7 patients. In 5 of these patients, the medio-lateral size of condylar heads on the right side was bigger than on the left one. Hypoplasia of the condylar head on both sides was observed only in one patient.

There was a deviation of cervical spine position toward the left side in 8 of 9 patients. In addition, a deviation of hyoid bone occurred toward the left side in 5 of 6 patients. It was noteworthy that in these 6 patients, a deviation in their hyoid bones and cervical spines was observed simultaneously. Moreover in all of them, their side of deviation in both structures was the same.

Asymmetry of the nasopharyngeal space in 9 patients was detected. In 7 of these patients, simultaneous asymmetry of the nasopharynx and a deviation of the cervical spine were defined. In 5 patients wherein they had a more enlarged diameter of the nasopharyngeal space on the right side, the cervical spine showed a deviation toward the opposite side.

The anterior-posterior position of the glenoid fossa on the right or left side was different in 10 patients. In 8 patients, the right-side glenoid fossa had a more anterior position than that of the left side. Of these patients, yaw in the mandible to the left side was detected in 6 patients. This event also occurred in 1 of 2 patients who had an anterior position of the glenoid fossa on the left side with yaw detected on the right side. The summary of our axial view data is described above in Table1.



(a)

(b)

Figure 2. a) Roll of the mandible in coronal view, b) 3D view of the same patient

Table 1. The findings in CBCT axial views of the asymmetric patients.

Case number	Gender	Age (Years)	History	Yaw			Zygoma size Diff.†	Sinus size Diff.	Orbital size Diff.	Diff.in form of optical canal	Diff. in ML¥ size of condyles	Deviation of cervical spine	Deviation of hyoid bone	Asymmetry of NP*** space	Diff. in position of glenoid fossa
				Mandible	Maxilla	Zygoma									
1	F	29	Asymmetry	+LT*	-	+ LT	–	–	–	–	+ ↑LT	+LT	+LT	–	–
2	M	22	Asymmetry and cleft	-	-	+ LT	–	+ ↑RT**	–	–	–	–	–	+ ↑RT	–
3	F	10	Asymmetry and cleft	-	+ LT	-	–	–	–	–	–	+LT	–	+ ↑RT	–
4	F	18	Asymmetry	+ LT	+ LT	+ LT	–	–	–	–	–	–	–	–	+ RT
5	F	17	Asymmetry	+ RT	-	-	–	–	–	–	–	–	–	–	+LT
6	M	23	Asymmetry	+ RT	+ LT	+ LT	–	+ ↑LT	–	–	+ ↑RT	+LT	+LT	+ ↑LT	+ RT
7	F	35	Asymmetry	+ LT	+ LT	+ LT	+ ↑LT	+ ↑LT	–	–	+ ↑RT	+LT	+LT	+ ↑RT	+ RT
8	F	20	Asymmetry and cleft	-	-	-	–	+ ↑LT	–	–	–	–	–	+ ↑RT	–
9	F	19	Asymmetry	+ LT	-	-	–	–	–	–	–	–	–	–	–
10	M	30	Asymmetry	+ RT	+ RT	+ RT	+ ↑LT	+ ↑LT	Not available	Not available	+ ↑RT	+LT	+LT	+ ↑RT	+ RT
11	F	18	Asymmetry	+ LT	+ LT	+ LT	–	+ ↑RT	–	–	–	–	–	–	+ RT
12	F	27	Asymmetry	-	-	-	–	+ ↑RT	–	–	–	–	–	–	–
13	F	21	Asymmetry	+ LT	-	-	–	–	–	–	–	–	–	–	–
14	F	22	Asymmetry	+ LT	+ LT	+ LT	–	–	–	–	–	+LT	–	+ ↑RT	+ RT
15	F	25	Asymmetry	+ LT	-	+ LT	–	–	–	–	+ ↑RT	+ RT	+ RT	+ ↑RT	+ RT
16	M	20	Asymmetry	+ LT	+ LT	LT +	+ ↑LT	+ ↑LT	–	–	+ ↑RT	+LT	+LT	+ ↑RT	+LT
17	F	9	Asymmetry and microsomia	+ LT	+ RT	+ RT	+ ↑LT	+ ↑LT	–	–	+ ↑LT	+LT	–	–	+ RT
18	F	26	Asymmetry	+ RT	-	-	–	–	–	–	–	–	–	–	–

†Difference ¥ Medio-lateral * RT and LT marks show the tendency of deformity toward the right or left side. The last column shows the anterior position of the glenoid fossa on the presented side.
**** ↑ shows larger size of the anatomical structure ***Nasopharyngeal**

Table 2. The Findings in CBCT coronal views of the asymmetric patients.

Case number	Gender	Age (Years)	History	Roll (cant)			Diff. in palatal height on right or left	Diff. in condylar neck height	Diff. in level of the glenoid fossa
				Mandible	Maxilla	Orbit			
1	F	29	Asymmetry	↑LT*+	↑LT +	↑LT+	–	LT > RT	↑LT+
2	M	22	Asymmetry and cleft	↑RT +	↑RT +	–	–	LT = RT	–
3	F	10	Asymmetry and cleft	–	–	–	–	LT = RT	–
4	F	18	Asymmetry	↑RT +	↑RT +	–	–	LT = RT	↑RT +
5	F	17	Asymmetry	–	↑LT+	–	–	LT = RT	↑LT+
6	M	23	Asymmetry	↑RT +	↑LT+	–	–	RT > LT	↑RT +
7	F	35	Asymmetry	↑LT+	↑LT+	–	↑LT+	RT > LT	↑LT+
8	F	20	Asymmetry and cleft	–	–	–	↑RT +	LT = RT	–
9	F	19	Asymmetry	–	↑LT+	–	–	LT = RT	–
10	M	30	Asymmetry	↑LT+	↑LT+	Not available	–	RT > LT	↑RT +
11	F	18	Asymmetry	–	↑RT +	–	–	RT > LT	↑RT +
12	F	27	Asymmetry	–	–	–	–	LT = RT	–
13	F	21	Asymmetry	↑RT +	↑LT+	–	↑RT +	RT > LT	↑RT +
14	F	22	Asymmetry	↑RT +	↑RT +	–	–	LT = RT	–
15	F	25	Asymmetry	↑LT+	↑LT+	–	–	LT = RT	↑LT+
16	M	20	Asymmetry	↑LT+	↑LT+	–	↑LT+	RT > LT	↑RT +
17	F	9	Asymmetry and microsomia	↑RT +	↑RT +	–	↑RT +	LT > RT	↑RT +
18	F	26	Asymmetry	↑LT+	–	–	–	RT > LT	–

* ↑ Signifies that the level of the normal landmark on that side is higher

Coronal view

Roll in the maxilla was found in 14 patients. In 5 patients, the roll of the maxilla was in the right side. In 8 patients both roll and yaw in maxilla were observed simultaneously.

In 12 patients, roll in mandible was observed. Eleven patients had simultaneous yaw and roll in the mandible; however, the direction of these deformities was similar in 5 cases.

Differences in the palatal depth on the right or left sides were detected in 5 patients. In 3 of these, the palatal depth on the right side was higher than on the left side. In addition, 4 of these 5 patients had roll in the maxilla, simultaneously.

Differences in the height of the condylar neck were found in 9 patients. In 7 patients, the height of the condylar neck on the right side was longer. Of these 9 patients, roll in the mandible occurred concurrently in 8 patients. In 3 patients, roll of the mandible occurred on the same side on which we detected a longer condylar neck.

Dissimilarities in the upper and lower levels of the glenoid fossa were defined in 11 patients. In 7 cases, the level of the right glenoid fossa was higher than on the left side. Of these 11 patients, 8 patients had a discrepancy in the height of their condylar necks. Six patients had a longer condylar neck and a higher level of glenoid fossa on the same side. Table 2 shows the summary of our coronal view data of all patients.

Discussion

The proper evaluation of the asymmetrical portion of facial structures thanks to its significant role in surgical and orthodontic treatment planning has been considered extensively in the recent years. Various radiological methods for identifying facial asymmetry have been evaluated by several researchers. Grayson et al[5] presented the combined usage of postero-anterior, lateral and submentovertex views for three-dimensional evaluation of jaw bone structures. Grummons and Kappeyne van de Coppello[10] stated that cephalometric views are succeptible to distortion, thus should be used comparatively rather than quantitatively. Quantitative measurement is a key element for the identification of asymmetry. Thus, three-dimensional analysis using cephalometric view could not be properly validated.

Cavalcanti et al [11] indicated that there were no statistically significant differences between linear measurements on CT and physical measurements in an in vitro study that confirmed the accuracy of the techniques. In spite of its benefits, clinicians are uncertain about using conventional CT because of the long procedure in a closed space and high level of radiation. [6]

Maeda et al [12] assessed facial asymmetry in 49 patients with maxillofacial deformity by using a 3D-CT imaging method based on coordinated three-dimensional point. They reported that the frequency of asymmetry was 8.2% in the body of the mandible, 18.4% in the mandibular ramus, 6.1% in the maxilla and 22.4% in all three regions.

In our study, maxillary asymmetry was observed in 15 patients (6 patients with roll, 1 patient with yaw and 8 patients with a combination of roll and yaw). Based on our combined findings, the asymmetry of the mandibular body in 8 patients and discrepancies in ramus length in 10 patients were detected. Simultaneous asymmetry of the mandibular ramus and body in 7 patients and in all three regions of the mandible, including the ramus, body and condylar neck were found in 6 patients. In our observation, the asymmetry of the maxilla was detected more frequently than in other facial structures.

Katsumata et al [4] assessed the degree of deformity in patients with facial asymmetry in comparison with a control group of subjects. They demonstrated that the use of 3D-CT imaging for the evaluation of the morphology of facial asymmetry is useful.

Hwang et al[6] investigated the reasons of chin deviation by using 3D views of spiral CT. They demonstrated that right-to-left differences in maxillary height, ramus length, frontal ramal and lateral ramal inclination as well as mandibular body length and height could be the causes of chin deviation.

In our the study, by comparing the patients' data, causes of chin deviation include the dissimilarities in the anterior-posterior position of the glenoid fossa, differences in condylar neck heights, as well as the presence of yaw in the mandible and roll in the mandible and maxilla.

Terajima et al[13] evaluated the morphology of various patients having maxillofacial deformity by using a standard Japanese three-dimensional head model and superimposing patient 3D-CT images on it.

In the present study, simultaneous occurrence of yaw in the maxilla, mandible and zygoma were observed in 8 patients. Observation of this simultaneous finding could be explained by considering the influence that growth of maxillofacial skeletal structures has on the each other. The concomitant deviations of the cervical spine and the hyoid bone were observed in all 6 patients with hyoid bone deviation. Indeed, a deviation of the cervical spines can affect facial musculature.

In this investigation, 7 of 10 patients, the direction of the mandibular yaw was detected going toward the opposite side of the anterior position of the glenoid fossa. This is presented as one of the reasons for mandibbular asymmetry which is not related to mandibular structure.

In this study, the thickness of the right and left zygomatic bones in 4 patients on the right or left side was different. Furst et al [14] assessed the application of CT for definition of the zygomatic complex position. They detected the zygomatic complex position in relation to the base of skull by using anatomic measurements. They suggested that dental practitioners can use variants such as posterior and anterior zygomatic complex width as well as zygomatic complex height to determine the degree to which facial asymmetry occurs in the zygomatic complex area.

Differences in the medio-lateral size of the orbit, and the anatomical shape and form of the optical canal were not observed in the patients we examined. This means that the orbital area may be influenced less frequently by asymmetry than other areas of the maxillofacial complex.

Roll in the mandible and maxilla was presented in 11 patients simultaneously. Approximately 9 patients had roll in the mandible and maxilla on the same side that confirmed the effect of mandibular and maxillary growth on each other.

Nine patients had differences in the height of their condylar necks. In 8 patients, mandibular roll was observed and in 3 patients, mandibular roll was observed on the same side on which there was a longer condylar neck. The mandibular roll could have occurred in compensation for condylar neck lengthening.

Concurrent occurrences of different positions of the glenoid fossa and the height of condylar neck could be related to a compensatory reaction. Thus, doing additional investigations to accept or reject this theory is highly necessary.

In a study by Kwon et al [15] on non-asymmetric subjects, there was a high negative correlation between the ramal height and body length. Their facial asymmetry patients revealed a shortening of the ramal and body length on the deviated side. They concluded that asymmetric mandibular growth factors compensate or aggravate the effect of the cranial asymmetry during the growth period.

Legrell and Isberg[16] reported a shorter ramus on the experimentally-induced disk displacement side that was partially compensated by the growth of mandible. Due to the compensatory effect of growth on reducing asymmetrical presentation, the importance of an exact diagnosis of asymmetry is clearly specified.

This study was performed as a starting point for further investigations into facial asymmetry. This subject, i.e the concomitant occurrence of asymmetry in different parts of facial structures, may provide a foundation for the future studies to be performed on this phenomenon with a greater sample size.

Conclusion

The results of this study revealed that CBCT was effective in the analysis of the details related to asymmetry and their effects on facial structures. It was also indicated that the effect of asymmetry on facial structures is so complicated that the surgical and orthodontic treatment plans should not be pursued without a prior consideration of the complexity and details of asymmetry. In addition, three-dimensional analysis helps us to select a certain diagnostic method for choosing a proper ortho-surgical plan.

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