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Effect of Head Misalignment in Horizontal & Vertical Dimensions on the Magnification Rate of Digital Panoramic Radiography in Different Parts of the Jaws

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ABSTRACT

Background and Aim: Considering the widespread development of implants in dental treatment plans, linear measurements on panoramic radiography are of especial importance. In the present study we investigated the effect of head misalignment up to 15° around vertical and horizontal axes on the magnification rate of digital panoramic radiography in each part of upper and lower jaws.
Methods and Materials: In this in vitro experimental study, five edentulous human skulls were used. Steel globes with 4mm diameter were placed inside each dental socket. Each skull was exposed twice at standard panoramic position and at 5, 10 and 15° upward, downward, left and right deviated positions with NewTom GIANO radiographic system with the least amount of kVp and mAs. All 50 images were saved in true size and the maximum horizontal and vertical diameter of each globe was measured by an oral and maxillofacial radiologist using linear measurement software. Data were statistically analyzed by Chi- square and ANOVA tests.
Results: At standard panoramic position, linear measurements in both horizontal and vertical dimensions showed magnification and the results indicated 12-13% magnification in vertical dimension in all parts of both jaws. The least rate of horizontal magnification was seen in the molar area of both jaws (6%). ($p<0.05$)
At lateral head rotation, linear measurements in vertical dimension were less affected. ($p>0.05$) Linear measurements in horizontal dimension showed the highest variations especially in the posterior parts of the jaws. ($p>0.05$)
At upward and downward chin rotations, vertical measurements showed magnification rate comparable with that of standard panoramic position while horizontal measurements showed increased magnification at upward rotation and decreased magnification during downward rotation. ($p>0.05$)
Conclusion: Vertical and horizontal linear measurements show magnification at standard panoramic position and also at lateral head rotation around Y-axis and at upward and downward rotations. Furthermore, even at deviations up to 15°, no minimized measurements were recorded in the obtained panoramic radiographs.

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Introduction:

Considering the widespread deployment of dental implants in dentistry treatment plans, more attention is being paid to the importance of radiography.[1] Panoramic radiography which has been introduced in 1952 by Paatero, can clearly visualize the location of inferior alveolar nerve and floor of the maxillary sinus in relation to the alveolar crest in edentulous areas and reveals beneficial information regarding the existence of pathologic lesions in the maxillofacial region. [2] Ease of interpretation and availability, low cost and low radiation dose have increased the popularity of this radiographic modality among dentists. [3] Some of the disadvantages of this radiography include magnification and image distortion due to the distance between x-ray source and object and image receptor. Besides, it cannot visualize bone thickness.[4] In one study, comparison between radiographies and anatomic samples showed that only 17% of measurements from the alveolar crest to the superior border of mandibular canal on panoramic radiography had the approximate accuracy of 1mm. [5] Dimensional accuracy in the horizontal dimension of panoramic radiography depends upon the position of objects relative to the central plane of focal trough. Generally, horizontal magnification in panoramic image varies from 0.7 to 2.2. [6] Magnification rate in panoramic radiograph highly depends on the radiographic system and in each radiographic device its approximate degree is known and declared by the manufacturer. In digital systems which are in widespread use nowadays, the magnification rate has been greatly reduced, based on the claims made by the manufacturing companies.[7] The accuracy of measurements on panoramic radiographs also depends on patient adjustments by the technician. In many radiographic devices, horizontal alignment of the head is done by the technician or the patient by use of a mirror while in the vertical dimension, the technician tries to improve the image of the anterior areas of the jaws through upwards and downwards chin adjustments.[3] All these factors affect the accuracy of linear measurements.

Investigations have shown that correct head position is important for the estimation of proper horizontal distances before implant placement. [8] The accuracy of vertical measurements is highly affected by rotation around horizontal and vertical axes.[9] Precise adjustment of the occlusal plane is also important.[10] Nevertheless, some novel articles insist that in many patients with no probable anatomic problems, the use of panoramic radiography and intraoral impressions seem sufficient for evaluation of the remaining ridge before implant placement and that computed tomography (CT) scan must be reserved for more complex cases.[7, 11, 12, 13]

Presuming that inaccurate adjustments in panoramic radiography produce image distortions which lead to radiography retake, in the present study we aimed to calculate the magnification rate of New Tom (GIANO, GENOVA, Italy) radiographic device at standard panoramic position and afterwards we measured the changes in magnification rate at 5, 10 and 15° upward, downward, left and right head deviations in horizontal dimension. Since this research has been performed in vitro and the changes have not produced considerable image distortions, we believe that these problems occur routinely during radiography and are usually ignored which shows the clinical importance of the present investigation in linear measurements performed by dentists.

Methods and Materials:

In this experimental study, 5 edentulous and intact human skulls were used. A piece of wax with 1.5 mm thickness was used in the joint space to artificially reconstruct the Temporomandibular joint. Steel globes with diameter of 4mm were placed inside dental sockets and were fixed with wax. Afterwards, each skull was fixed in CR position using tape and was placed in a carton in a way that the occlusal plane was tilted 20 to 30° downwards relative to the horizon. In this way, the line connecting the tragus and outer cantus of the eye would be parallel to the floor. Each skull was placed on a camera stand (Zeiss universal Tripod, FT 6302, Germany, Oberkochen) which allowed rotations in vertical and horizontal dimensions.[14] The degree of deviation was adjusted by use of a conveyor. Each skull was placed inside NewTom (GIANO, GENOVA, Italy) digital panoramic imaging system and was exposed twice at standard position with the least amount of exposure settings (kVp=60, mA=1, s=9.3 seconds). Then, each skull was rotated 5, 10 and 15° to the right in horizontal dimension and was exposed twice with the mentioned exposure settings. The exposures were repeated for left side rotation. Afterwards, the skulls were returned to the standard position and they were tilted upwards and downwards to the mentioned degrees in vertical dimension and were exposed twice. The computer files of the obtained radiographies were saved in true size. An oral and maxillofacial radiologist measured the maximum horizontal and vertical diameter of each globe on the radiographs with use of the measurement software of radiographic system. The measurements were repeated a week later by the same radiologist. Data were entered into SPSS software and were statistically analyzed using Chi- square and ANOVA tests.

Results:

The findings of the present study separated by research steps are as follows: 1) Magnification rates at standard position:

After measuring the vertical and horizontal diameter of each globe, each jaw was divided to four regions: Left and right central and lateral incisors, left and right canines, left and right first and second premolars, left and right first, second and third molars of upper and lower jaws. Magnification rate of each region is presented separately in Table 1.

Table 1 – Magnification in horizontal and vertical dimensions at standard panoramic position

Dental region	Diameter	Mean diameter on radiograph ± SD	P-value	Magnification
UL and R incisors	horizontal	4.37±.40	.034	9.21%
	vertical	4.51±.08	.000	12.65%
UL and R canines	horizontal	4.36±.41	0.000	9.06%
	vertical	4.50±.04	.000	12.5%
UL and R premolars	horizontal	4.34±.23	.004	8.59%
	vertical	4.51±.04	.000	12.81%
UL and R molars	horizontal	4.60±.10	.000	6%
	vertical	4.65±.18	.001	12%
LL and R incisors	horizontal	4.44±.24	.001	10.93%
	vertical	4.54±.14	.000	13.59%
LL and R canines	horizontal	4.53±.12	0.000	13.12%
	vertical	4.53±.12	.003	13.12%
LL and R premolars	horizontal	4.41±.18	.000	10.31%
	vertical	4.56±.10	.000	13.90%
LL and R molars	horizontal	4.24±.20	.003	6.02%
	vertical	4.53±.10	.000	13.18%

R= right, LL= lower left, UL= upper left

2) Magnification rates in skulls deviated in horizontal dimension are summarized in Tables 2 and 3.

Table 2 – Magnification in horizontal and vertical dimensions during 5, 10 and 15° chin deviation to the right.

Dental region	Deviation	Mean vertical diameter on radiograph ±SD	p-value	Vertical magnification	Mean horizontal diameter on radiograph ±SD	p-value	Horizontal magnification
U and LL incisors	5° right	4.54±.06	.087	%13	4.35±.47	.265	%8
U and LL canines		4.58±.05	.103	%14	4.38±.57	.704	%9
U and LL premolars		4.57±.05	.015	%14	4.38±.30	.291	%9
U and LL molars		4.66±.07	.537	%16	4.49±.17	.634	%12
U and LR incisors		4.48±.03	.516	%12	4.24±.16	.252	%6
U and LR canines		4.18±.09	.495	%4	4.43±.13	.382	%10
U and LR premolars		4.59±.07	.685	%14	4.32±.11	.129	%8
U and LR molars		4.55±.07	.574	%13	4.3±.19	.075	%7
U and LL incisors	10° right	4.51 ±.04	.161	%12	4.38±.67	.027	%9
U and LL canines		4.4±.09	.319	%10	4.33±.72	.294	%8
U and LL premolars		4.57±.06	.010	%14	4.37±.36	.036	%9
U and LL molars		4.59±.07	.913	14%	4.48±.33	.715	12%
U and LR incisors		4.6±.10	.502	%15	4.38±.10	.015	%9
U and LR canines		4.18±.06	1.000	%4	4.5±.09	.411	%12
U and LR premolars		4.6±.12	.451	%15	4.4±.12	.028	%10
U and LR molars		4.63±.07	.610	%15	4.5±.18	.028	%12
U and LL incisors	15° right	4.57±.07	.083	%14	4.27±.19	.080	%6
U and LL canines		4.55±.06	.604	%14	4.35±.11	.430	%8
U and LL premolars		4.63±.08	.015	%15	4.4±.13	.108	%10
U and LL molars		4.64±.12	.472	%15	4.53±99	.434	%13
U and LR incisors		4.6±.07	.490	%15	4.27±.16	.070	%6
U and LR canines		4.2±.12	.867	%5	4.43±.13	.493	%10
U and LR premolars		4.53±.06	.714	%13	4.27±.16	.120	%6
U and LR molars		4.57±.07	.181	%14	4.22±.13	.048	%5

U= upper,
LL= lower left,
LR= lower right

Table 3 – Magnification in horizontal and vertical dimensions during 5, 10 and 15° chin deviation to the left.

Dental region	Deviation	Mean vertical diameter on radiograph ±SD	p-value	Vertical magnification	Mean horizontal diameter on radiograph ±SD	p-value	Horizontal magnification
U and LL incisors	5° left	4.58±.08	.732	%14	4.28±.19	.067	%7
U and LL canines		4.25±.07	.789.	%6	4.48±.75	.321	%12
U and LL premolars		4.54±.12	.164	%13	4.59±.40	.028	%14
U and LL molars		4.66±.07	.528	%16	4.59±.40	.203	%14
U and LR incisors		4.52±.07	.794	%13	4.09±.97	.068	%2
U and LR canines		4.58±.15	448	%14	4.28±.19	.401	%7
U and LR premolars		4.55±.05	.634	%13	4.23±.16	.123	%5
U and LR molars		4.65±.11	.360	%16	4.25±.17	.031	%6
U and LL incisors	10° left	4.54±.08	.108	%13	4.22±.13	.102	%5
U and LL canines		4.18±.05	1.000	%4	4.48±1.27	.447	%12
U and LL premolars		4.55±.11	.020	%13	4.53 ±99	.079	%13
U and LL molars		4.64±.12	.548	16%	4.5±.24	.923	12%
U and LR incisors		4.49±.08	.702	%12	4.05.±99	.121	%1
U and LR canines		4.5±.14	.161	%12	4.33±1.12	.389	%8
U and LR premolars		4.53±.10	.577	%13	4.28±.6	.165	%7
U and LR molars		4.58±.07	.283	%14	4.28±.15	.044	%7
U and LL incisors	15° left	4.54±.13	.359	%13	4.28±.19	.068	%7
U and LL canines		4.45±.17	.769	%11	4.4±.13	.368	%10
U and LL premolars		4.48±.09	.155	%12	4.43±.10	.009	%10
U and LL molars		4.52±.12	1.000	%13	4.39±.12	.349	%9
U and LR incisors		4.48±.11	.666	%12	4.14±.97	.058	%3
U and LR canines		4.45±.16	.710	%13	4.38±.11	.464	%9
U and LR premolars		4.57±.12	.351	%14	4.37±.10	.035	%9
U and LR molars		4.64±.08	.121	%16	4.48±.33	.024	%12

U= upper, LL= lower left, LR= lower right

At head rotation in horizontal dimension, after measuring the vertical and horizontal diameter of each globe, each jaw was divided to four regions as follows:

Table 4 - Magnification in horizontal and vertical dimensions during 5, 10 and 15° upward chin deviation.

Dental region	Deviation	Mean vertical diameter on radiograph ±SD	p-value	Vertical magnification	Mean horizontal diameter on radiograph ±SD	p-value	Horizontal magnification
UR and L incisors	5° UP	4.66±.17	.067	16.56%	4.53±.18	.172	13.12%
UR and L canines		4.50	1.000	12.5%	4.40.±29	.681	10%
UR and L premolars		4.64±.15	.060	15.93%	4.48±.20	.123	11.87%
UR and L molars		4.70±.07	.394	17.5%	4.68±.16	.356	17%
LR and L incisors		4.60±.21	.208	15%	4.54±.37	.163	13.43%
LR and L canines		4.68±.21	.173	16.87%	4.65±.26	.430	16.25%
LR and L premolars		4.59±.11	.405	14.68%	4.46±.19	.252	11.56%
LR and L molars		4.55±.10	.412	13.86%	4.28±.22	.020	7.04%
UR and L incisors	10° UP	4.45±.09	.161	11.25%	4.69±.11	.102	17.18%
UR and L canines		4.53±.05	.495	13.12%	4.53±.13	.440	13.12%
UR and L premolars		4.5±6.05	.104	14.06%	4.48±.07	.209	11.87%
UR and L molars		4.68±.08	.756	17%	4.66±.13	.261	16.5%
LR and L incisors		4.60±.31	.598	15%	4.68±.73	.255	16.87%
LR and L canines		4.55±.13	.848	13.75%	4.65±.44	.440	16.25%
LR and L premolars		4.50±.14	.357	12.5%	4.41±.34	1.000	10.31%
LR and L molars		4.60±.11	.002	15%	4.26±.22	.461	6.59%
UR and L incisors	15° UP	4.63±.17	.151	15.62%	5.39±.52	.009	34.68%
UR and L canines		4.55±.06	.252	13.75%	4.85±.44	.119	21.25%
UR and L premolars		4.54±.18	.732	13.43%	4.59±.24	.052	14.68%
UR and L molars		4.62±.08	.795	15.5%	4.84±.33	.090	21%
LR and L incisors		4.56±.13	.800	14.06%	5.20±.87	.015	30%
LR and L canines		4.53±.10	1.000	13.12%	4.88±.38	.529	21.87%
LR and L premolars		4.54±.11	.623	13.43%	4.50±.24	.329	12.5%
LR and L molars		4.57±.13	.227	14.31%	4.34±.22	.024	08.40%

L= left,
UR= upper right,
LR= lower right

upper and lower central and lateral incisors, upper and lower canines, upper and lower first and second premolars, upper and lower first, second and third molars on the left and right sides.

3) Magnification rates in skulls deviated in vertical dimension

At upward and downward head rotation in vertical dimension, each jaw was divided to four regions :left and right central and lateral incisors, left and right canines, left and right first and second premolars, left and right first, second and third molars of upper and lower jaws. Magnification rate of each region is presented in tables 4 and 5.

Table 5 - Magnification in horizontal and vertical dimensions during 5, 10 and 15° downward chin deviation.

Dental region	Deviation	Mean vertical diameter on radiograph ±SD	p-value	Vertical magnification	Mean horizontal diameter on radiograph ±SD	p-value	Horizontal magnification
UR and L incisors	5° down	4.43±.34	.420	10.62%	4.28±.31	.557	6.87%
UR and L canines		4.5±3.13	.769	13.12%	4.15±.38	.088	3.75%
UR and L premolars		4.54±.05	.275	13.43%	4.25±.21	.189	6.25%
UR and L molars		4.68±.16	.591	17%	4.58±.15	.541	14.5%
LR and L incisors		4.49±.08	.331	12.18%	4.18±.35	.009	4.37%
LR and L canines		4.55±17	.848	13.75%	4.23±.19	.317	5.62%
LR and L premolars		4.58±.15	.754	14.37%	4.36±.21	.227	9.06%
LR and L molars		4.55±.10	.629	13.36%	4.23±.11	.767	5.68%
UR and L incisors	10° down	4.54±.09	.588	13.43%	4.13±.40	.000	03.12%
UR and L canines		4.53±.05	.495	13.12%	4.03±.44	.002	00.62%
UR and L premolars		4.56±.14	.381	14.6%	4.23±.18	.016	05.62%
UR and L molars		4.66±.05	.910	16.5%	4.52±.13	.294	13%
LR and L incisors		4.55±.08	.923	13.75%	4.23±.21	.002	05.62%
LR and L canines		4.53±.05	1.000	13.12%	4.43±.17	.346	10%
LR and L premolars		4.56±.14	.890	14.06%	4.29±.20	.005	07.18%
LR and L molars		4.5±3.20	1.000	13.18%	4.25±.16	.743	06.36%
UR and L incisors	15° down	4.51±.11	.915	12.81%	3.99±.08	.023	0.310%
UR and L canines		4.48±.17	.804	11.87%	4.08±.29	.294	01.87%
UR and L premolars		4.56±.14	.366	14.06%	4.28±.23	.461	06.87%
UR and L molars		4.72±.13	.567	18%	4.50±.25	.486	12.5%
LR and L incisors		4.65±.09	.077	16.25%	4.30±.50	.328	07.5%
LR and L canines		4.65±.13	.229	16.25%	4.28±.43	.297	06.87%
LR and L premolars		4.66±.12	.031	16.56%	4.37±.36	.605	09.37%
LR and L molars		4.57±.19	.461	14.31%	4.31±.32	.322	07.72%

L= left, UR= upper right, LR= lower right

Discussion:

Based on the primary principles of radiology, to obtain the most accurate radiograph, the image receptor must be placed at minimum distance and parallel to the radiographed object and the x-ray must be projected perpendicular to the image receptor and the object. Since in panoramic radiography which is an extra oral radiographic method, it is not possible to place the film adjacent to dental tissues and on the other hand due to the specific topography of the device, the beam is projected at -5 to -7 degrees, magnification is an inseparable part of the obtained image. [1]In digital panoramic radiography performed during

In digital panoramic radiography performed during the present study, both horizontal and vertical dimensions were magnified. Magnification was higher in vertical dimension but with smaller variations; that is, all the jaw areas were evenly magnified. Magnification is constant in vertical jaw measurements and approximates 12-13%, although this contradicts the study by Kim et al which stated that vertical magnification is higher in maxilla compared with that of mandible.[15] This controversy can be attributed to the use of different imaging systems. In horizontal di-

different imaging systems. In horizontal dimension, magnification variations are higher but the least degree of magnification was found in the posterior area of mandible and maxilla.Numerous studies have evaluated the prevalence of technical errors in panoramic radiography. (16) The majority of them related the most common error to the space between the tongue and palate in adults and patient movement during radiography and backward chin position in children. (17, 18) Downward and upward chin rotations are in next ranks (19, 20) while lateral head rotation is less common. (21) It should be considered that detection of errors is subjective in panoramic radiography. Therefore, if errors are considerable they will produce radiographic views and when they are limited to few degrees, they will be overlooked by the technician and the practitioner.

In the present study, when chin was deviated in horizontal dimension, the teeth on a single region of upper and lower jaws on one side were considered as a single unit and were compared with corresponding teeth on the contralateral region which were moving away from the x- ray receptor. During lateral head rotation (around vertical axis) linear measurements in vertical dimension were less affected which was predictable considering the x-ray projection path but it should be noted that even at 15° deviation from the standard position, the sizes were not minimized. Only in the canine area of the side to which the head had rotated, vertical magnification was reduced: that is, vertical size in the canine area on the deviated side approximated the actual size which is noteworthy from clinical point of view. It is worth mentioning that when deviation angle is increased in horizontal dimension, magnification rate does not follow a stable pattern. Furthermore, the degree of magnification relative to the magnification at standard position is not statistically significant. ($p>0.05$)

At head rotation around Y-axis, horizontal measurements are more affected. It is worth mentioning that in the present study, even at head rotations up to 15°, measurements were not minimized. Maximum variations were measured in posterior jaw areas and magnification rate showed a bigger percentage on the contralateral side compared with the ipsilateral head rotation side. It should be considered that in some panoramic imaging systems, the film rotates from right to left and in some others, the film rotates from left to right and this can justify the unpredictability of magnification rate at different jaw parts during head rotation. (14)

During upward head deviation, magnification in vertical dimension increases but it does not follow a stable pattern unlike the situation in standard position. Although with increasing the angle, magnification rate does not follow a constant pattern but it is higher in the maxilla compared with the mandible; that is, in the mandible with increased chin deviation up to 15°, magnification remains within the standard range especially in the posterior areas (12-14 degrees). During downward chin deviation, magnification in vertical dimension remains almost constant and within the standard range with up to 10° of deviation but upon increasing the angle towards 15°, magnification in upper jaw decreases while longitudinal vertical sizes in the lower jaw increase. Considering the negative inclination of x-ray tube in panoramic radiography, constant magnification below 10° of deviation can be considered to counteract the innate negative angle of the device and at angles over 10°, vertical linear measurements begin to distort. Horizontal magnification is highly affected by chin deviation around horizontal axis. At upward chin rotation, with increasing the angle, magnification in horizontal measurements increases significantly. It seems that during upward chin deviation, the jaws are moving away from the detector of x-ray source and magnification in the image of the under study structures becomes effective on linear measurements. At rotations above 10°, image distortion is added to horizontal magnification. At downward chin rotation, magnification also reduces and although with increasing the angle up to 15°, horizontal measurements in some cases reach the actual size of the globes but the sizes are never minimized. It seems that during downward chin rotation, the jaws are moving close to the x-ray detector and this is an important factor in decreasing the magnification.(14)

Variations in linear measurements during head rotations around horizontal axis have been investigated more widely than the variations during rotation along vertical axis. This shows that variations in linear measurements during lateral head rotations are expected. However, our study showed that vertical linear measurements are less affected by head rotation in horizontal dimension and at below 10°. In a study by Nikneshan et al accuracy of linear and angular measurements in head rotations less than 10° has been evaluated and they stated that there were no significant changes at below 8° lateral and upward head rotations. Our study approves the mentioned results. [22]

Stramotas et al assessed linear and angular measurements on an artificial jaw model and showed that accurate adjustment of the occlusal plane and avoiding tilts above 10° in vertical dimension significantly affect the accuracy of linear and angular measurements. [10] This result is in accordance with our findings.

Sadat-khonsari and colleagues performed a study to evaluate the effect of patient's head tilt in panoramic radiography on vertical linear measurements in ramus and condylar region. They showed that a difference up to 6% in linear measurements on both sides of mandible especially posterior regions and ramus is related to inaccurate adjustment of the patient's head while higher difference values can be related to jaw asymmetry. [9]

In a research by Abdinia et al, magnification in different jaw areas at 10° chin deviation in vertical dimension was assessed. In the mentioned study, with increased upward chin deviation, magnification in both horizontal and vertical dimensions was measureable and with increasing downward chin deviation in horizontal dimension, the sizes were minimized in most areas. In terms of reduced horizontal magnification during downward chin deviation, the mentioned results are in line with ours but we did not record any minimized sizes in our measurements which can be attributed to the focal troughs of radiographic devices or sizes of the skulls used in the two studies. [14]

Conclusions:

Panoramic radiography at standard position (1:1) shows magnification in both horizontal and vertical dimensions. During lateral head rotations, vertical magnification remains constant while magnification in horizontal plane varies. Moreover, during upward and downward head rotations around horizontal axis, magnification can be seen in both horizontal and vertical dimensions. At chin deviations up to 15°, jaw magnification does not follow a stable pattern.

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References:

1. Ogawa K, Langlais RP, McDavid WD, Noujeim M, Seki K, Okano T, et al. Development of a new dental panoramic radiographic system based on a tomosynthesis method. Dentomaxillofac Radiol 2010;39(1): 47-53.
2.Siu AS, Chu FC, Li TK, Chow TW, Deng FL. Imaging modalities for preoperative assessment in dental implant therapy:an overview. Hong Kong Dent J 2010;7:23-30.
3. Berkhout WE, Beuger DA, Sanderink GC, Van der Stelt PF .The dynamic range of digital radiographic systems: dose reduction or risk of overexposure? Dentomaxillofac Radiol 2004;33(1):1–5.
4. Tyndall DA, Brooks SL. Selection criteria for dental implant site imaging: a position paper of the American Academy of Oral and Maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000; 89(5):630-7.
5.Tronje G, Eliasson S, Julin P, Welander U. Image distortion in rotational panoramic radiography. II. Vertical distances. Acta radiologica: diagnosis 1981; 22(4):449-55.
6.Volchansky A, Cleaton-Jones P, Drummond S, Bonecker M. Technique for linear measurement on panoramic and periapical radiographs: a pilot study. Quintessence Int 2006;37(3):191-7.
7.Vazquez L, Saulacic N,Belser U,Bernard JP.Efficacy of panoramic radiographs in the pre-operative planning of posterior mandibular implants:a prospective clinical study of 1527 consecutively treated patients. Clin Oral Implants Res 2008;19(1):81-5.
8.Pfeiffer P,Bewersdorf S,Schmage P.The effect of changes in head position on enlargement of structures during panoramic radiography. Int J oral Maxillofac Implants 2012;27(1):55-63.
9.Sadat-Khonsari R, Fenske C, Behfar L, Bauss O. Panoramic radiography: effects of head alignment on the vertical dimension of the mandibular ramus and

condyle region. Eur J Orthod 2012;34(2):164-9.
10. Stramotas S, Geenty JP, Petocz P, Darendeliler MA. Accuracy of linear and angular measurements on panoramic radiographs taken at various positions in vitro. Eur J Orthod 2002;24(1):43-52.
11. Frei C, Buser D, Dula K. Study on the necessity for cross-section imaging of the posterior mandible for treatment planning of standard cases in implant dentistry. Clin Oral Implants Res 2004;15(4):490–7.
12. BouSerhal C, Jacobs R, Quirynen M, van Steenberghe D. Imaging technique selection for the pre-operative planning of oral implants: a review of the literature. Clin Implant Dent Relat Res 2002;4(3):156–72.
13. Guerrero M, Jacobs R, Loubele M, Schutyser F, Suetens P, van Steenberghe D. State-of-art on cone beam CT imaging for pre-operative planning of implant placement. Clin Oral Investig 2006;10(1):1–7.
14. Abdi nia M ; Ghorbanzadeh S,Jafari nadiki H. Effect of changes in Chin position in the plane vertical to the panoramic image magnification in different parts of the jaw. Journal of Isfahan Dental School 2012;8 (4):306-313
15. Kim YK, Park JY, Kim DG, Kim JS ,Kim JD, Magnification rate of digital panoramic radiographs and its effectiveness for pre-operative assessment of dental implants; Dentomaxillofacial Radiol 2011;40(2):76-83.
16. Schiff T, D›Ambrosio J, Glass BJ, Langlais RP, McDavid WD. Common positioning and technical errors in panoramic radiography J Am Dent Assoc 1986;113(3):422-6
17. Boeddinghaus R, Whyte A. Dental panoramic tomography: an approach for the general radiologist. Australas Radiol 2006;50(6):526-33.
18. Murray D, Whyte A. Dental panoramic tomography: what the general radiologist needs to know. Clin Radiol 2002;57(1):1-7.
19. Yeo DK, Freer TJ, Brockhurst PJ. Distortions in panoramic radiographs. Aust Orthod J 2002;18(2):92-8.
20. Sant›Ana LF, Giglio FP, Ferreira O Jr, Sant›ana E, Capelozza AL. Clinical evaluation of the effects of radiographic distortion on the position and classification of mandibular third molars. Dentomaxillofac Radiol 2005;34(2):96-101.
21. Peretz B, Gotler M ,Kaffe I. Common errors in digital panoramic radiographs of patients with mixed dentition and patients with permanent dentition. Int J Dent 2012;2012:1-7.
22. Nikneshan S, Sharafi M, Emadi N. Evaluation of the accuracy of linear and angular measurement on panoramic radiographs taken at different positions. Imaging Sci Dent 2013;43(3):191-6.