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Cone Beam Computed Tomographic Measurements of the Descending Palatine Canal and Pteryogomaxillary Region: Implications for Le Fort I Maxillary Osteotomy

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Abstract

Aims: To provide cone-beam computed tomographic (CBCT) measurements of the descending palatine canal (DPC) and pterygomaxillary region, and to demonstrate any possible variations by age, gender and skeletal patterns in a Jordanian population. This may help oral and maxillofacial surgeons (OMFS) in planning and executing a safe Le Fort I maxillary osteotomy.

Materials and methods: This radio-anatomical study evaluated CBCT radiographs for patients aged ≥ 18 to 40 years and treated over five years. Distances representing anterior and posterior lengths from the DPC, the narrowest width of pterygoid plates, the depth and diameter of the DPC, and the posterior width of the maxilla were measured by a reliable examiner. Measurements were analyzed according to patients' age, gender, and skeletal patterns. Student's t-test and One-Way-ANOVA test were used to analyze data.

Results: A total of 93 CBCT radiographs were evaluated and related to a cohort of 93 subjects; 35 (37.6%) males and 58 (62.3%) females, and a mean age (± SD) of 28.98 ± 6.78 years. Almost all measured distances showed significant ($P < 0.05$) greater values in males than females. Only the posterior width recorded statistically significant ($P < 0.05$) different distances among the three skeletal pattern groups. All various distances were significantly ($P < 0.05$) higher in the older age group (30-40 years) than the young age group (18-29 years).

Conclusion: CBCT measurements of the pterygomaxillary region, particularly in the young age group and females, with class III skeletal pattern, can provide the safest Lefort I maxillary osteotomy design.

Keywords: cone-beam computed tomography; descending palatine canal; Le Fort I.

INTRODUCTION

Le Fort I maxillary osteotomy is the standard orthognathic surgical procedure commonly performed by OMFS for the correction of a wide range of dentofacial deformities [1]. It entails maxillary downfracture after complete osteotomies to the posterior and lateral maxillary walls directed to the ipsilateral piriform rim, osteotomies of the lateral nasal wall, separation of the nasal septum, and pterygomaxillary dysjunction [1]. However, these osteotomies, along with the manipulation of the downfractured maxillary bone, in particular the DPC and pterygomaxillary junction, made the procedure labeled as a challenging procedure. This is due to the limited access, the critical location of the pterygomaxillary junction and the close proximity to vital anatomical structures, most importantly the base of skull and descending palatine artery (DPA) [2-4]. Therefore, this surgical procedure may be complicated by severe hemorrhage, unfavorable split and base of skull fractures or injuries to important cranial nerves [5-7].

Ample literature recommended perioperative great caution [2-6, 8, 9] aiming at minimizing the risks to the important structures posed by Le Fort I maxillary osteotomy. In addition, the knowledge and better understanding of vital anatomical structures, in particular the DPC and pterygomaxillary junction, were agreed to increase the safety of Le Fort I maxillary osteotomies. This was based on reports related osteotomy complications to the positioning and depth of osteotomy cuts [8, 10].

Very few previous studies published in the English literature only described various anatomical and radiological linear measurements for the DPC and pterygomaxillary junction in relation to different populations, such as those of the United States of America (USA) [11], Thailand [12], and Japan [9]. However, only one recent study analyzed these measurements in relation to gender, and craniofacial morphology and patterns in the Brazilian population [13]. To the authors' knowledge, there have been no reports in relation to the Jordanian population and to the influence of age on these measurements. Hence, the aim of this study was to provide, using CBCT radiographs, linear measurements of the DPC and pterygomaxillary region, and to demonstrate any possible differences by age, gender and skeletal patterns in a Jordanian population. This may help the OMFS in the clinical risk management, and in planning and executing a safe Le Fort I maxillary osteotomy.

MATERIALS AND METHODS

Study subjects

The retrospective design of this radio-anatomical study and reviewing all CBCT radiographs available at Jordan University Hospital (JUH) for the purpose of this study were approved by the Research Ethics Committee at JUH (reference number 10/2023/186689). This study was also conducted in full accordance with the Declaration of Helsinki. All CBCT radiographs for patients aged ≥ 18 to 40 years (most common age range indicated for orthognathic surgery) who had also a lateral cephalogram and treated in the departments of Orthodontics and Maxillofacial Surgery at JUH over the last five years, from July 2018 to July 2023, were primarily included. However, CBCT radiographs showing poor diagnostic viewing quality, syndromic or developmental deformities altering maxillary morphology, or signs of maxillary pathological lesions as well as evidence of previous maxillary surgery or trauma, were all excluded.

CBCT radiographs

All CBCT radiographs used in this study were acquired by a senior radiology technician, implementing a standard imaging protocol at the JUH and the manufacturer's instructions. This was achieved using a CBCT scanner (CS 9300. Carestream Health, Inc., 10622 AL 93 SS 0314, France, 2014), with the same setting; 60–90 kVp and 2–15 mA at different resolutions, an exposure time of 4–16 s, a voxel size of 90–300 µm considering the field of view and a slice thickness of 2 mm.

Inter-observer reliability

All CBCT radiographs used in this study were assessed by the same observer (a senior resident in OMFS) who underwent through two stages before conducting final measurements of all distances used in this study. The first stage comprised practical calibration sessions on recognizing the DPC and other concerned landmarks, and demonstrations on enhancing the CBCT software program to measure distances between the concerned landmarks. These calibration sessions were presented to the observer by the senior maxillofacial radiologist and surgeon (MA) at the JUH. The second stage entailed requesting the calibrated observer to measure the required distances on a set of CBCT radiographs not included in the study, and then requesting the maxillofacial radiologist to re-measure these distances. Differences between these two measurements were then analyzed to assess the inter-observer reliability. This was achieved by conducting the intraclass correlation coefficient (ICC), which indicated an excellent level of agreement (P = 0.000 - 0.002) between the two measurements, with an overall range from 77.7 to 99.5%, with 95% confidence interval (CI) of 0.328–0.999 for all various measurements. This stage was considered successfully completed and suggested that the observer was reliable.

CBCT analysis and evaluation techniques

The process of CBCT analysis was undertaken by the calibrated observer on anonymized patient demographic details. The CBCT software program was enhanced to ensure a standardized head position and an optimal visualization, brightness and contrast values of the study radiographs. In addition, the software produced axial, coronal, sagittal, and 3-dimentional reconstructions to exactly recognize the DPC and other concerned landmarks (Figure 1). The axial reconstruction view was mainly generated at a level of 3 mm above the nasal floor and used to provide valid, comparable and reproducible distances (in millimeters) (Figure 2), as proposed by Ueki et al [9] and Oliveira et al [13].

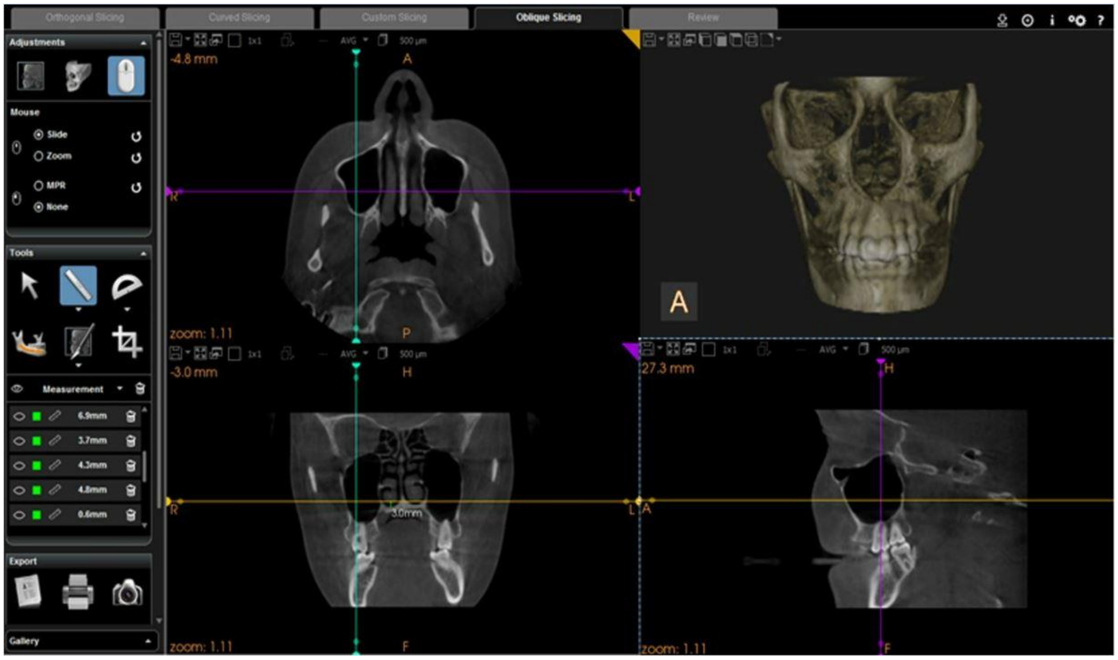

Figure 1 Reconstructed axial, coronal, 3-dimentional and sagittal cone-beam computed tomographic (CBCT) views. The axial view was generated at a level of 3 mm above the nasal floor and used to assess the location of the descending palatine canal (DPC) and other related landmarks.

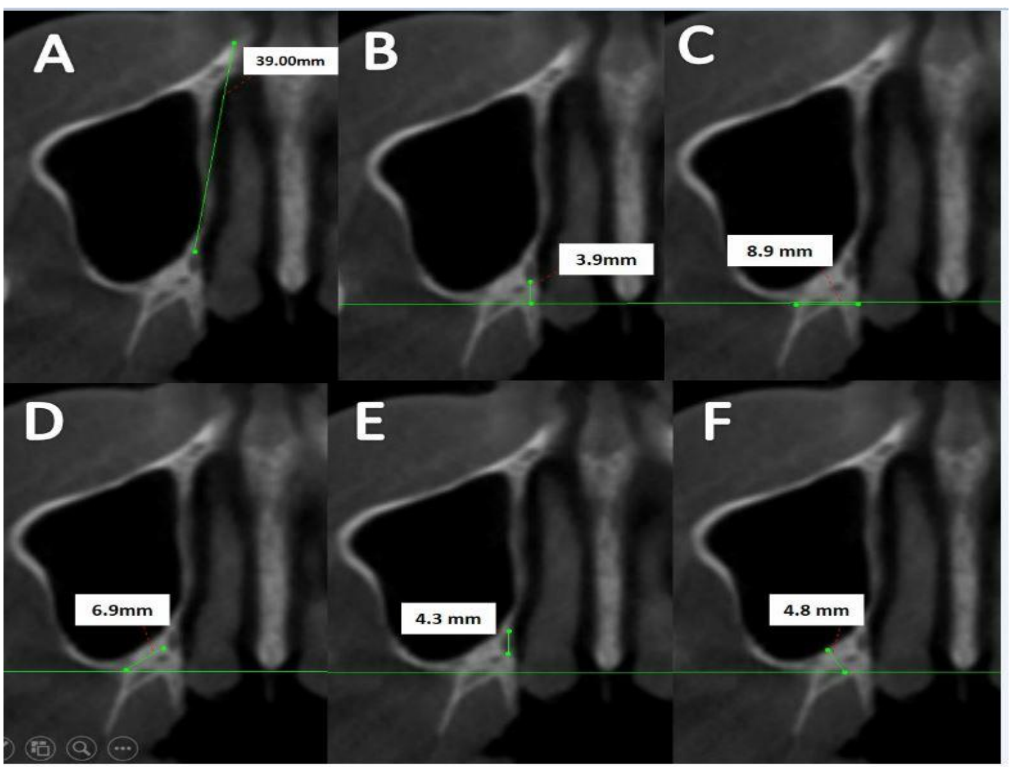

Figure 2 The axial reconstruction view generated at a level of 3 mm above the nasal floor, with the software ruler used to provide measurements of the descending palatine canal (DPC) and specific landmarks (in millimeters): A: anterior length; B: posterior length; C: width of the pterygoid plates; D: depth of the DPC; E: diameter of the DPC; F: posterior width of the maxilla.

- Distance A: represented the anterior length and measured between the most anterior points of both the DPC and the lateral wall of the piriform rim (Figure 2A).
- Distance B: represented the posterior length and measured between the most posterior points of both the DPC and the pterygomaxillary fissure line (Figure 2B).
- Distance C: represented the narrowest width of the pterygoid plates and measured between the lateral and the medial pterygoid plates at the pterygomaxillary fissure line (Figure 2C).
- Distance D: represented the depth of the DPC and measured between the most lateral points of both the DPC and the pterygomaxillary fissure (Figure 2D).
- Distance E: represented the diameter of the DPC and measured between the most anterior and posterior points of the canal (Figure 2E).
- Distance F: represented the posterior width of the maxilla and measured between the most anterior point of the pterygomaxillary fossa and the most posterior point of the maxillary sinus (Figure 2F).

All distances for each study CBCT radiograph were measured on the right and left sides, separately. The lateral cephalogram was also used to determine patients' skeletal patterns, using the ANB angle (the angle formed by point A, nasion, and point B), according to cephalometric norms for a Jordanian population, which were very close to Eastman standards [14], and accordingly classified patients into three groups: class I (normal ANB), class II (increased ANB), and class III (decreased ANB). Patients' demographic details were recorded and patients were then classified into two age groups; young (18-29 years), and older (30-40 years). This age classification was based on the fact demonstrated in the literature [3, 15] and in recent studies on the same population [10, 16] that maxillary and mandibular bone mass is gained at the end of the second decade of life and goes on by remodeling processes until reaching the adult size (40 years). In addition, the bone remodeling changes and density of the jaws were demonstrated to be significantly age-related and greater in patients over 30 years of age [17].

Intra-observer reliability and power analysis

To assess the intra-observer reliability, the same calibrated observer was requested to re-measure all distances in a two-month interval, and the ICC was then conducted between the two measurement sessions. The statistical power of this study was retrospectively calculated using the statistical software package G*Power version 3.1.5 (Franz Faul, Universität Kiel, Kiel, Germany, 1992). One-Way-ANOVA test of independent means (three groups) was set as statistical test to perform power analysis for skeletal pattern comparisons, and simple t-test of independent means (two groups) was set as statistical test to perform power analysis for age and gender comparisons, both using $\alpha=0.05$, sample size of 93 subjects valid for analysis, and large effect size=0.80 (F test) or 0.4 (t test); it is possible to detect such an effect in smaller sample numbers.

Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences for Windows version 19 (SPSS, Chicago, IL, USA). The data was normally distributed, and was described via means and standard deviations. The intra-observer reliability was assessed using the ICC. Paired-sample t-test was used to analyze side differences. Student's t-test was used to analyze gender differences, in the entire cohort and within the same age and skeletal pattern groups. One-Way-ANOVA test was used to analyze differences among the three skeletal pattern groups, with the post hoc Tukey test for multiple comparisons to detect the statistical significance for each pair of means of the skeletal pattern groups. Statistical significance was set at $P < 0.05$ at 95% confidence intervals.

RESULTS

Study subjects

Out of a total of 116 CBCT radiographs initially met the inclusion criteria and examined for this study, 23 were excluded; nine showed poor diagnostic quality, three showed syndromic and developmental deformities altering maxillary morphology, five showed signs of maxillary pathological lesions, and six showed evidence of previous maxillary surgery as well as trauma. Therefore, the final sample size comprised a total of 93 CBCT radiographs related to a cohort of 93 patients; with a gender distribution of 35 (37.6%) males and 58 (62.3%) females, and a mean age (± SD) of 28.98 ± 6.78 years (range 18–40 years).

Intra-examiner reliability and power analysis

The overall ICC ranged from 95.0% to 99.7%, with 95% confidence interval (CI) of 0.925–0.998 for all various measurements, and indicated a significant ($P < 0.001$) level of intra-observer agreement between the two measurement sessions conducted by the same reliable observer (Table 1). Analysis computation yielded a statistical power of 93.4% for the analysis of the skeletal pattern, 98.1% for the analysis of gender and 98.4% for the analysis of age, suggesting that the statistical effects of the skeletal pattern, age and gender were properly detected by the present study.

Table 1 Intra-observer reliability.

Variable	Intraclass Correlation Coefficient (ICC)	95% confidence interval		*P-value**
		Lower bound	Upper bound	
Distance A	0.994	0.991	0.996	**< 0.001**
Distance B	0.950	0.925	0.967	**< 0.001**
Distance C	0.986	0.979	0.991	**< 0.001**
Distance D	0.983	0.975	0.989	**< 0.001**
Distance E	0.995	0.992	0.996	**< 0.001**
Distance F	0.997	0.995	0.998	**< 0.001**

*Intraclass Correlation Coefficient (ICC); Distance A: Anterior Length; Distance B: Posterior Length; Distance C: Width of the pterygoid plates; Distance D: Depth of the descending palatine canal; Distance E: Diameter of the descending palatine canal; Distance F: Posterior width of the maxilla.

Side differences

Paired-sample t-test indicated that side differences for all various measured distances were not statistically significant ($P > 0.05$) (Table 2) therefore, the average distances of the right and left side measurements were calculated and adopted for later statistical analyses.

Table 2 Comparison of the distances between the right and left sides of the maxilla for males and females (N=93).

Variable		Gender			
		Male (n=35) Mean ± SD	*P-value**	*Female (n=58) Mean ± SD*	*P-value**
Distance A	Right	38.71 ± 1.76	0.298	37.58 ± 1.93	0.129
	Left	38.68 ± 1.73		37.54 ± 1.97	
Distance B	Right	2.85 ± .93	0.399	2.46 ± .82	0.059
	Left	2.77 ± .78		2.38 ± .79	
Distance C	Right	8.00 ± 1.00	0.228	7.38 ± 1.09	0.517
	Left	7.99 ± 1.01		7.37 ± 1.07	
Distance D	Right	5.29 ± 1,00	0.167	4.67 ± 1.10	0.214
	Left	5.25 ± 1.03		4.64 ± 1.06	
Distance E	Right	3.44 ± .53	0.382	3.10 ± .56	0.087
	Left	3.42 ± .55		3.08 ± .54	
Distance F	Right	2.93 ± .93	0.065	2.82 ± .98	0.372
	Left	2.87 ± .95		2.81 ± 1.10	

Paired-sample t-test (significance of right to left); SD: Standard deviation; Distance A: Anterior Length; Distance B: Posterior Length; Distance C: Width of the pterygoid plates; Distance D: Depth of the descending palatine canal; Distance E: Diameter of the descending palatine canal; Distance F: Posterior width of the maxilla.

Gender differences

All measured distances, with the exception of the posterior width of the maxilla (Distance F), showed significant ($P < 0.05$) greater values in males than in females (Table 3, Table 4). When the skeletal pattern was considered, only the anterior (Distance A) and posterior (Distance B) lengths were significantly ($P < 0.05$) higher in class III male subjects than class III females (Table 3). When the age group was considered, only the anterior length (Distance A), the width of the pterygoid plates (Distance C), and the depth (Distance D) and diameter (Distance E) of the DPC were significantly ($P < 0.05$) higher in young (18-29 years) male subjects than young females (Table 4).

Table 3 Comparison of the average distances among skeletal pattern groups, in the entire cohort and within the same gender, and between males and females, in the entire cohort and within the same skeletal pattern group (N=93).

Variable	Skeletal pattern	Gender						
		Male *n (mean ± SD)*	**P***	**Female** *n (mean ± SD)*	**P***	**P****	**Total** *n (mean ± SD)*	**P***
Distance A	**Class I**	9 (39.09 ± 1.10)	0.514	24 (38.10 ± 2.04)	0.191	0.180	33 (38.37 ± 1.85)	0.081
	Class II	8 (38.11 ± 1.77)		23 (37.10 ± 2.03)		0.220	31 (37.36 ± 1.99)	
	Class III	18 (38.77 ± 2.02)		11 (37.34 ± 1.30)		**0.047**	29 38.23 ± 1.89)	
	Total	35 (38.70 ± 1.74)		58 (37.56 ± 1.95)		**0.006**	93 (37.99 ± 1.94)	

Variable	Skeletal pattern	Gender						
		Male n (mean ± SD)	P*	Female n (mean ± SD)	P*	P**	Total n (mean ± SD)	P*
Distance B	**Class I**	9 (2.83 ± 0.66)	0.832	24 (2.55 ± 0.94)	0.543	0.421	33 (2.62 ± **0**.87)	0.542
	Class II	8 (2.66 ± 0.93)		23 (2.35 ± 0.78)		0.364	31 (2.43 ± **0**.81)	
	Class III	18 (2.8 ± 0.87)		11 (2.26 ± 0.34)		**0.034**	29 (2.64 ± **0**.77)	
	Total	35 (2.81 ± 0.81)		58 (2.41 ± 0.79)		**0.022**	93 (2.56 ± **0**.82)	
Distance C	**Class I**	9 (8.19 ± 0.545)	0.711	24 (7.67 ± 1.17)	0.213	0.212	33 (7.81 ± 1.06)	0.133
	Class II	8 (7.78 ± 1.08)		23 (7.13 ± 1.11)		0.161	31 (7.29 ± 1.12)	
	Class III	18 (7.98 ± 1.17)		11 (7.27 ± **0**.61)		0.0724	29 (7.71 ± 1.04)	
	Total	35 (7.99 ± 1.01)		58 (7.38 ± 1.08)		**0.008**	93 (7.61 ± 1.09)	
Distance D	**Class I**	9 (5.46 ± 0.56)	0.749	24 (4.94 ± 1.17)	0.237	0.211	33 (5.08 ± 1.06)	0.163
	Class II	8 (5.08 ± 1.12)		23 (4.42 ± 1.11)		0.156	31 (4.59 ± 1.13)	
	Class III	18 (5.26 ± 1.16)		11 (4.55 ± **0**.60)		0.073	29 (4.99 ± 1.04)	
	Total	35 (5.27 ± 1.01)		58 (4.66 ± 1.07)		**0.008**	93 (4.89 ± 1.09)	
Distance E	**Class I**	9 (3.50 ± 0.29)	0.883	24 (3.24 ± **0**.59)	0.213	0.227	33 (3.31 ± **0**.53)	0.200
	Class II	8 (3.36 ± 0.56)		23 (2.97 ± **0**.57)		0.102	31 (3.07 ± **0**.58)	
	Class III	18 (3.42 ± 0.63)		11 (3.02 ± **0**.29)		0.058	29 (3.27 ± **0**.56)	
	Total	35 (3.43 ± 0.53)		58 (3.09 ± **0**.54)		**0.005**	93 (3.21 ± **0**.56)	
Distance F	**Class I**	9 (3.23 ± 0.66)	0.147	24 (2.99 ± 1.05)†	**0.016**	0.541	33 (3.06 ± **0**.95) †	**0.008**
	Class II	8 (3.10 ± 1.05)		23 (2.89 ± **0**.93) ‡		0.601	31 (2.94 ± **0**.95) ‡	
	Class III	18 (2.55 ± 0.95)		11 (2.07 ± **0**.55) †‡		0.102	29 (2.35 ± **0**.85) †‡	
	Total	35 (2.85 ± 0.94)		58 (2.77 ± **0**.980		0.689	93 (2.80 ± **0**.96)	

*****ANOVA test (significance among skeletal pattern groups); ******Student's t-test (significance of male to female); †, ‡post hoc multiple comparisons; **SD:** Standard deviation; Distance A: Anterior Length; Distance B: Posterior Length; Distance C: Width of the pterygoid plates; Distance D: Depth of the descending palatine canal; Distance E: Diameter of the descending palatine canal; Distance F: Posterior width of the maxilla.

Table 4 Comparison of the average distances between the two age groups, in the entire cohort and within the same gender, and between males and females, in the entire cohort and within the same age group (N=93).

Variable	Age group (years)	Gender						
		Male *n (mean ± SD)*	P*	Female *n (mean ± SD)*	P*	P**	Total *n (mean ± SD)*	P*
Distance A	**(18-29) yrs**	17 (37.88 ± 1.36)	**0.005**	35 (36.76 ± 1.50)	**< 0.001**	**0.012**	52 (37.13 ± 1.53)	**< 0.001**
	(30-40) yrs	18 (39.47 ± 1.74)		23 (38.77 ± 1.95)		0.241	41 (39.08 ± 1.87)	
	Total	35 (38.70 ± 1.74)		58 (37.56 ± 1.95)		**0.006**	93 (37.99 ± 1.94)	
Distance B	**(18-29) yrs**	17 (2.29 ± 0.52)	**< 0.001**	35 (2.12 ± 0.50)	**< 0.001**	0.270	52 (2.17 ± 0.51)	**< 0.001**
	(30-40) yrs	18 (3.31 ± 0.73)		23 (2.86 ± 0.94)		0.104	41 (3.06 ± 0.87)	
	Total	35 (2.81 ± 0.81)		58 (2.41 ± 0.79)		**0.022**	93 (2.56 ± .82)	
Distance C	**(18-29) yrs**	17 (7.45 ± 0.85)	**0.001**	35 (6.92 ± 0.82)	**< 0.001**	**0.036**	52 (7.09 ± 0.86)	**< 0.001**
	(30-40) yrs	18 (8.50 ± 0.88)		23 (8.07 ± 1.06)		0.178	41 (8.26 ± 1.10)	
	Total	35 (7.99 ± 1.01)		58 (7.38 ± 1.08)		**0.008**	93 (7.60 ± 1.09)	
Distance D	**(18-29) yrs**	17 (4.72 ± 0.87)	**0.001**	35 (4.19 ± 0.80)	**< 0.001**	**0.033**	52 (4.36 ± 0.85)	**< 0.001**
	(30-40) yrs	18 (5.79 ± 0.87)		23 (5.37 ± 1.06)		0.185	41 (5.55 ± 0.99)	
	Total	35 (5.27 ± 1.01)		58 (4.66 ± 1.07)		**0.008**	93 (4.89 ± 1.09)	
Distance E	**(18-29) yrs**	17 (3.13 ± 0.44)	**0.001**	35 (2.87 ± 0.42)	**< 0.001**	**0.039**	52 (2.95 ± 0.44)	**< 0.001**
	(30-40) yrs	18 (3.71 ± 0.47)		23 (3.43 ± 0.55)		0.100	41 (3.55 ± 0.53)	
	Total	35 (3.43 ± 0.53)		58 (3.09 ± 0.54)		**0.005**	93 (3.22 ± .56)	
Distance F	**(18-29) yrs**	17 (2.47 ± 1.10)	**0.017**	35 (2.37 ± 0.75)	**< 0.001**	0.685	52 (2.40 ± 0.83)	**< 0.001**
	(30-40) yrs	18 (3.21 ± 0.73)		23 (3.37 ± 1.00)		0.565	41 (3.30 ± 0.89)	
	Total	35 (2.85 ± 0.94)		58 (2.77 ± 0.98)		0.689	93 (2.80 ± .96)	

*Student's t-test (significance of the young to the older age groups); **Student's t-test (significance of male to female); SD: Standard deviation; Distance A: Anterior Length; Distance B: Posterior Length; Distance C: Width of the pterygoid plates; Distance D: Depth of the descending palatine canal; Distance E: Diameter of the descending palatine canal; Distance F: Posterior width of the maxilla.

Skeletal pattern and age differences

Table 3 shows that only the posterior width of the maxilla (Distance F) recorded statistically significant ($P < 0.05$) different distances among the three groups of the skeletal pattern (class I subjects recorded the highest values, followed by class II, and then class III subjects), overall and only within the female gender; Post hoc analysis revealed that this significance was observed between class I and class III subjects, and between class II and class III subjects. Table 4 showed that, in general, the measurement values for all various distances were significantly ($P <$

0.05) higher in the older age group (30-40 years) than the young age group (18-29 years), overall and within the same gender.

DISCUSSION

The better understanding of linear measurements of the DPC and pterygomaxillary region, and their possible variations by age, gender, and skeletal patterns can provide the OMFS with the safest osteotomy design and surgical instrumentation tailored to the individual anatomical variations [12, 18]. CBCT was well suited to provide linear measurements in the maxillofacial region, with high accuracy and reproducibility, and with several advantages over other advanced radiographs [19, 20].

In Le Fort I osteotomy, the lateral nasal osteotome is used to osteotomize the lateral nasal wall along the anterior length (Distance A), with great caution not to extend the osteotomy further posteriorly to avoid injury to the DPA contained in the canal [21]. Injury to the DPA can lead to profuse bleeding and considered an important complication of the procedure, along with other possible consequences, such as aneurysm formation and bleeding in the postoperative period [21, 22]. Therefore, the knowledge of this distance would determine how much the surgeon can safely advance the lateral nasal osteotome posteriorly without injuring the DPA [1, 11]. In this study, the anterior length measured a mean value of 37.99 mm, with a minimum length of 34.17 mm and maximum length of 41.87 mm. These measurements were nearly close to the CBCT measurements reported in the study of Oliveira et al [13] (mean: 38.06 mm, range: 30.90-46.20 mm), in Brazil, and Reidel [11] (mean: 38.40 mm, range: 34.40-42 mm), in USA, but higher than measurements made on human dry skulls by Cheung et al [18] (mean: 34.1 mm, range: 23.8-41.0 mm) on a population of Asian origin. The diversity in these measurements was attributed to the influence of increased proportion of class III subjects in the population sample of Asian origin [13, 18]. In this study, male subjects measured significant higher anterior lengths than females, overall and only within class III subjects. In contrast, male class II subjects measured significant higher anterior lengths than female class II subjects in the study of Oliveira et al [13] in Brazil. However, gender differences were not significant in the study of Apinhasmit et al [12]. Similarly, the knowledge of the posterior length (Distance B) and its possible variations may help in identifying the proximity of the DPC to the osteotomy line made at the pterygomaxillary junction and posterior maxillary wall. Some studies [9] located the DPC, in a very few cases, exactly in the pterygomaxillary fissure. Therefore, when this distance is shorter, osteotomies of the pterygomaxillary junction and posterior maxillary wall may carry greater risk of injury to the DPA [9, 11]. In this study, the posterior length was also significantly greater in male subjects than females, overall and within class III subjects. This was in concordance with the findings of the study of Oliveira et al [13], in Brazil, which reported significant greater posterior distances in male subjects, but with no differences among skeletal pattern groups. When age was considered in this study, the anterior and posterior lengths measured significant greater distances in the older age group. Therefore, anterior and posterior length measurements in this study would suggest higher risk of injury to the DPA in the young age group, females and class III female subjects in the Jordanian sample; this was due to the shorter distance that the osteotome can be safely used before reaching the DPC in the reduced anterior and posterior lengths measured in these cohorts [8, 9]. This was generally in agreement with reports recommending posterior advancement of the lateral nasal osteotome along the anterior length no more than 30 mm in females and 35 mm in males after opening the piriform [11].

In this study, the width of the pterygoid plates (Distance C) represented the mediolateral thickness of pterygoid plates at the pterygomaxillary fissure line. This method of measurement was similar to that used in few previous reports [8, 13], but different from others [23] measuring this distance between the pterygomaxillary fissure and pterygoid plates. This distance was considered an important predictor of safe pterygomaxillary separation; the smaller the width, the higher the risk of pterygoid fractures [8]. In general, the literature [23] reported an average distance of 4.7 mm among cases in which pterygoid fractures occurred. In this study, this average distance was 7.71 mm and significantly greater in males than females, with no differences among skeletal pattern groups. This was suggesting a low risk of pterygoid fractures in this population, but a greater chance among females was observed. Interestingly, the study of Oliveira et al [13], in Brazil, used the same methodology used in this study and reported an average width of 7.68 mm, but with no significant gender and skeletal pattern group differences. Similarly, the depth of the DPC (Distance D) has been linked to the risk of injury to the DPA [2]; the risk was greater among cases with reduced average measurements [24]. In this study, this average distance was significantly greater in males than females, with no differences among skeletal pattern groups. This suggested a greater risk of injury to the DPA in females than males and thereby, greater caution should be taken during osteotomy of maxillary tuberosity in females compared with males. This was nearly consistent with a recent study [13], in Brazil, measured significant reduced measurements among females, but with significant differences among skeletal pattern groups.

The diameter of the DPC (Distance E) has been related to the risk of injury to the DPA; the larger the diameter, the greater the chance of injury to the DPA [3, 9]. However, it was suggested that a larger diameter of the DPC might compensate for the reduced blood flow that may occur in maxillary impaction or advancement [24]. In this study, the DPC measured a significant greater diameter in males than females, with no differences among skeletal pattern groups. In contrast, Oliveira [13], in Brazil, measured a larger diameter of the DPC only among class III males.

Regarding the posterior width of the maxilla (Distance F), it was linked to the risk of fracture of pterygoid plates [2]; the risk was greater among cases with average measurements between 3.6 mm and 2.6 mm, but was smaller among cases with measurements less than 2.6 mm. Ethnic variations were claimed for such differences [2]. In this study, the posterior width measured an average distance of 2.8 mm, suggesting a higher risk of fracture of pterygoid plates in this population. Furthermore, this study indicated significant smaller posterior width measurements in the class III skeletal pattern group compared to class I and class II groups, overall and only within female subjects. This suggested a greater risk of pterygoid fractures in class III female subjects than class II and class I females. This was consistent with a recent study in Brazil [13], which reported an average posterior width of 2.96 mm, with significant gender and skeletal pattern group differences similar to this study.

When age was considered in this study, measurements of the width of the pterygoid plates and depth of the DPC suggested higher risk of fracture of pterygoid plates and injury to the DPA during pterygomaxillary separation or osteotomy of maxillary tuberosity in the young age group female subjects of the Jordanian population. Similarly, posterior width measurements would suggest higher risk of fracture of pterygoid plates in the young age group, but with no gender differences. One of the explanations was that, in the smaller measurements of these three distances, the stress created by the pterygoid osteotome might be dissipated into the pterygoid plates or the osteotome might be lodged near or between the pterygoid plates or shortly reaching the DPA, thereby increasing the risk of unfavorable split to the pterygoid plates instead of separation, or injuring the DPA [2, 8]. In contrast, greater distances of the DPC diameter in this study were measured in the older age group male subjects, suggesting higher risk of injury to the DPA [3, 9] in this cohort of the Jordanian population.

In this study, the older age group generally measured greater distances than the young age group. This is consistent with reports on "evidence of tendency for the maxilla to become more prognathic with growth, when the younger age groups were compared with adults" [11]. Furthermore, recent reports stated that the gain of bone mass goes on until the adult size, reaching the maximum at the age of 40 years [15, 25]. Nevertheless, to the authors' knowledge, the age of the patient and its influence on the measurements studied herein were not considered in any previous study. In addition, only one study [13] analyzed these measurements in relation to gender and skeletal patterns, so there was a limitation in comparison of the findings with other studies. Thus, further studies on these measurements according to age and other factors, and in other populations are recommended.

CONCLUSION

The better understanding of linear CBCT measurements of the DPC and pterygomaxillary region, particularly in the young age group and females, in particular with class III skeletal pattern, can provide the OMFS with the safest Lefort I maxillary osteotomy design and surgical instrumentation tailored to the individual anatomical variations

Disclosure

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قياسات باستعمال الصور الطبقية قمعية الحزمة للقناة الحنكية المنحدرة والمنطقة الجناحية للفك العلوي: أهميتها لجراحة الفك العلوي في مستوى ليفورت 1

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الملخص

الأهداف: اجراء قياسات باستعمال الصورة الطبقية قمعية الحزمة للقناة الحنكية المنحدرة والمنطقة الجناحية للفك العلوي، وايضاح الفروقات الناتجة عن العمر، الجنس، والنموذج الهيكلي في السكان الأردنيين. هذا الأمر قد يساعد جراحي الفم والفكين في التخطيط والتنفيذ لجراحة الفك العلوي في مستوى ليفورت 1 وبشكل آمن.

منهجية البحث: هذه الدراسة الشعاعية التشريحية قيمت الصور الطبقية قمعية المقطع لمرضى أعمارهم 40–18 ≥ عاماً وتمت معالجتهم خلال الخمس سنوات الأخيرة. المسافات التي تمثل الأطوال الأمامية والخلفية من القناة الحنكية المنحدرة، والعرض الأقل للصفائح الجناحية، عمق وقطر القناة الحنكية المنحدرة والعرض الخلفي للفك العلوي كلها تم قياسها من خلال فاحص معتمد. تم تحليل هذه القياسات بناء على عمر المريض، جنسه، ونموذجه الهيكلي. تم تحليل النتائج باستخدام (One way ANOVA) و (Student t-test).

النتائج: تم تقييم (93) صورة طبقية قمعية الحزمة لـ 93 شخص، 35 (37%) ذكور، 58 (62.3%) اناث، وبمعدل عمر وانحراف معياري يساوي (6.28 ± 28.98). كل المسافات المقاسة كانت تقريباً أكبر وبشكل دال احصائياً (P<0.05) عند الذكور أكثر من الاناث. فقط العرض الخلفي شمل فروقات دالة احصائياً بناء على النموذج الهيكلي للمريض. كل القياسات كانت أكبر عند كبار السن من الصغار وبشكل دال احصائياً (P<0.05).

الخلاصة: القياسات باستعمال الصورة الطبقية قمعية المقطع للمنطقة والقناة الجناحية للفك العلوي، وخاصة عند صغار السن والاناث ممن لديهم سوء اطباق هيكلي من التصنيف الثالث، يزود جراح الوجه والفكين بتصميم اكثر اماناً لجراحة الفك العلوي في مستوى ليفورت 1.

الكلمات الدالة: الصورة الطبقية قمعية المقطع، القناة الحنكية المنحدرة، ليفورت 1