Clinical and Experimental Health Sciences

The Relationship Between Hand Preference and Mandibular Asymmetry: A Preliminary Study

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ABSTRACT

Objective: The objective of this study was to evaluate the relationship between functional laterality (hand preference) and mandibular asymmetry in skeletal Class I, normodivergent patients.

Methods: 21 left-handed and 40 right-handed Class I normodivergent patients were included in the study. The hand preferences of the participants were determined by using the Oldfied hand preference questionnaire. Mandibular condylar height (CH), ramal height (RH), and total height (CH+RH) were measured on pretreatment panoramic radiographic images of the patients, and asymmetry values were obtained according to the formula of asymmetry indices. Data were analyzed with the Student's t-test and Pearson chi-square.

Results: Right and left CH values were greater in left-handed patients than in right-handed patients. Right and left RH and CH+RH values were greater in right-handed patients than in left-handed. However, there was no difference between the measurements ($p > .05$). There was no significant relationship between the functional values and hand-use preference ($p > .05$).

Conclusions: Hand use preference was not associated with condylar, ramal, and total mandibular asymmetry.

Keywords: Hand preference, facial asymmetry, functional laterality, malocclusion, panoramic radiographs, orthodontics

1. INTRODUCTION

Directional asymmetries are divergences of bilateral symmetry that appear by choice on the right or left side (1). The asymmetry of the skull is also reported to be directional and appears as larger left sphenoid, malar, and occipital bones compared to the right, while the parietal, temporal, and frontal bones differ in opposite and the internal length of the skull is smaller on the left than the right (2). Interestingly; directional craniofacial asymmetries have been related to cerebral asymmetries associated with functional lateralities (such as hand, foot, and eye preferences used in daily activities) (3,4). Hand preference is the most investigated type of functional laterality and is defined as the typical preference of one hand over the other in various tasks performed in daily life (5). While the left hemisphere of right-handed individuals is reported to be dominant, the right cortex of individuals with left-handedness is defined as the dominant hemisphere to a large extent (6). It has been suggested that the asymmetrical development of brain regions may be causing the asymmetric craniofacial structures (4) and the asymmetric craniofacial structures can be expected to be reflected in lower facial asymmetries or malocclusions (7). Hand use preference that was reported to be accompanied by cerebral asymmetries (6) was previously associated with facial asymmetry (4,8), unilateral Angle Class II malocclusions (9), hemifacial microsomia (10), and unilateral crossbites (11) Since mandibular asymmetry, which can naturally occur in most subjects (12) is reported to be the primary marker of facial asymmetry (13) it can be expected that functional laterality, handedness, may be associated with mandibular asymmetry.

Studies on this topic are quite old. The aim of the present study is to evaluate the relationship between the ramal, condylar, and total mandibular asymmetry and functional laterality (hand preference) in skeletal Class I, normodivergent patients and to present a current perspective.

2. METHODS

This study was approved by the Clinical Research Ethics Committee of the Faculty of Medicine, Akdeniz University (Approval number: KAEK-450) before the commencement of the present study.

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2.1. Data Collection

Data were collected from the Akdeniz University, Faculty of Dentistry, Department of Orthodontics archives between 2012 and 2020. Pretreatment panoramic radiographs of 150 patients with no previous orthodontic treatment history, dental Class I molar relationships, ANB angle (0° ≤ ANB ≤ 5°; skeletal Class I relationship), normodivergant (28° ≤ SNGoGN ≤ 36°) vertical skeletal pattern, nonocclusions or posterior crossbites in transverse plane were evaluated (13).

The following radiologic inclusion criteria were used for digital panoramic radiographic images (DPRIs) of selected patients: *(1) the presence of normal coronoid processes and the condyle in DPRIs, (2) the presence of all teeth germs whether a third molar germ exists or not, (3) no acquired or developmental neuromuscular or craniofacial deformities and (4) no history of trauma.* DPRIs wherein temporomandibular joint pathology or craniofacial trauma was suspected, poor image quality with horizontal distortions, wherein anatomic landmarks for performing linear measurements were not visualized, were excluded. Considering the exclusion criteria, a total of 61 participants were included in the study.

The Oldfied hand-use preference questionnaire (14) modified by Geschwind and Behan (15) was transferred to the “Google Forms” (Google Inc., California, USA) website, and a special link for the survey was created. the created link was delivered to the participants via “WhatsApp” (Meta Inc, California, USA). The patients were informed about the questionnaire and the questionnaire was filled out voluntarily. At the top of the questionnaire, there was a statement that the participants participated in the study voluntarily.

This questionnaire consists of 10 questions (Figure 1). Response options were evaluated as “always with the right hand” (+ 10 points), “usually right hand” (+ 5 points), “with both hands” (0 points), “usually with left hand” (-5 points), and “always with the left hand” (-10 points). The results obtained as a result of scoring were evaluated according to the score of Geschwind and Behan (15-17) According to the score of Geschwind and Behan, the sum of the above scores determines the laterality score. The distribution of points is as follows: Strong right-hand users: +80 to +100 poiright-handright hand users: +20 to +75 points, both-handed: – 15 to +15 points, weak left-hand users: – 20 to – 75 points, anleft-handleft hand users: – 80 to – 100 points. In this study, individuals with a score of +20 to +100 were considered “right-handedness”, and individuals with a score of – 20 to – 100 were considered “left-handedness”. Both – handed (-15 to +15 points) participants and patients who incompletely filled out the hand-use preference questionnaire were not included in the study.

	always right	usually right	both hand	usually left	always left
Writing					
Painting					
Throwing					
Holding scissors					
Holding toothbrush					
Holding knife					
Holding spoon					
Holding handle for a shovel					
Striking a match					
Twisting off the lid of a jar					

Figure 1. *Ten questions of the Oldfied hand preference questionnaire which was modified by Geschwind and Behan (15)*

2.2. Mandibular Dimensions

DPRIs were gained with the same device (Planmeca ProMax; Planmeca Oy, 00880 Helsinki, Finland) by the same x-ray technician. All DPRIs were assessed using the same monitor by the same observer (H.T.A.) who has eight years of experience in oral radiology. Ten DPRIs were evaluated per day for preventing observer fatigue.

Anatomical points and lines were detected according to Habets et al. (18) (Figure 2) and linear measurements were measured on DPRIs on both the right and left sides:

Figure 2. *Linear measurements on the panoramic radiographic image: Co: the most superior part of the condyle; O1 and O2: the most lateral points of the condyle; A line: a ramus tangent B line: a perpendicular line from Co to A line; CH: Condylar height; RH: Ramal height; CH+RH: Total height*

Condylar height (CH): measurement between Co and O1 points

Ramal height (RH): measurement between O1 and O2 points

Total height (CH+RH): measurement between Co and O2 points

All measurements were automatically calibrated by the Planmeca Romexis 4.0 software program, which was developed for the Planmeca ProMax machine (Planmeca Oy, 00880 Helsinki, Finland).

The asymmetry indices were obtained by the following formula:

Asymmetry Index (AI) = [(Right – Left)/(Right + Left)] × 100

The value obtained as a result of the formula was recorded as "asymmetry presence" if ≥ 3%, and as " asymmetry absence" if < 3%. If the measurements made on the left are greater than the right, negative values were obtained as a result of the formula, and in the presence of a negative value, it was accepted that the left side was more dominant than the right side.

After 4 weeks, all measurements were repeated for all patients, and intra-observer variability was assessed.

2.3. Statistical Analysis

Data were statistically analyzed by using IBM SPSS Statistics (version 23.0, IBM, Armonk, NY). Quantitative variables among the groups were compared using the student's t-test. Pearson chi-square test was used to analyze the difference between categorical variables. Intra-observer reliability for numerical data was assessed by the interclass correlation coefficient. Because the intra-observer reliability was high, initial measurements were used for analysis, and statistical significance was accepted at $p < .05$.

3. RESULTS

The correlation coefficient was high and it was above 0.90 in all measurements. A total of 61 participants, including 40 females (65.6%), and 21 males (34.4%) were included in the study. The mean age was 13.52 ± 3.1 years (the age range was between 10 and 25 years). There were 41 (67.2%) right-handedness participants and 20 (32.8%) left-handedness participants. No statistically significant relationship was found between hand use preference and gender and age ($p > .05$). 42 (68.9%) of the participants had condylar asymmetry, 23 (37.7%) had ramal asymmetry and 22 (36.1%) had total asymmetry. No statistically significant relationship was found between gender and condylar, ramal, and total asymmetry ($p > .05$). In addition, there was no significant relationship between age and condylar, ramal, and total asymmetry ($p > .05$). Table 1 presents the number of female and male patients according to right-handedness, left-handedness, condylar asymmetry, ramal asymmetry, and total asymmetry.

Table 2 presents the descriptive data of measurements for both sides, regardless of the hand-use preference. The differences between the right and left side measurements of the CH, RH, and CH+RH weren't significant ($t(120) = – .668$, $p > .05$ for CH, $t(120) = – .387$, $p > .05$ for RH, and $t(120) = – .498$, $p > .05$ for CH+RH).

Table 3 presents the comparison of the right and left side measurements according to hand preference. There was no significant difference between the right and left side measurements of the CH, RH, and CH+RH considering the hand use preference ($p > .05$)

Table 4 presents the comparison of all measurements in right-handedness and left-handedness. While right and left CH values were greater in left-handedness than right-handedness, right and left RH and CH+RH values were greater in right-handedness than left-handedness. However, there was no significant difference between the measurements ($p > .05$).

Table 5 presents the relationships between the hand use preference and AI values and AI measurements of the condyle, ramus, and condyle+ramus were not statistically affected by the hand use preference ($p > .05$).

Table 1 *Number of female and male patients*

Gender	Right handedness (n)	Left handedness (n)	CA presence (n)	CA absence (n)	RA presence (n)	RA absence (n)	TA presence (n)	TA absence (n)
Female	26 (%63,41)	14 (%70)	29(%69,05)	11(%57,89)	14(%60,87)	26(%68,42)	14(%63,64)	26(%66,67)
Male	15 (%36,59)	6 (%30)	13(%30,95)	8 (%42,11)	9 (%39,13)	12(%31,58)	8 (%36,36)	13(%33,33)
p	.611		.396		.547		.811	

n: number of patients; %: percentages; CA: condylar asymmetry, RA: ramal asymmetry; and TA: total asymmetry

Table 2 *The mean, standard deviation, minimum, maximum and p values of the condylar, ramal and condylar+ramal height measurement for the left and right sides*

Parameter	n	Mean (mm)	SD	min	max	t	p
right CH	61	8.22	2.09	4.1	14.9	-.668	.505
left CH	61	8.47	2.05	4.7	15.4		
right RH	61	59.48	9.07	41.7	79.1	-.387	.699
left RH	61	60.14	9.63	42.8	78.8		
right CH+RH	61	67.7	9.65	47.6	89.9	-.498	.620
left CH+RH	61	68.6	10.44	47.5	93.1		

CH: condylar height; RH: ramal height; CH+RH: total height; n: number of patients; mm: millimeter; SD: standard deviation; min: minimum; max: maximum

Table 3. *The comparison of the right and left side measurements according to hand preference*

	right handedness			
	right mean (mm) ± SD	left mean (mm) ± SD	t	p
CH	8.13 ± 1.75	8.24 ± 1.51	-.302	.764
RH	61.2 ± 7.78	61.78 ± 8.99	-.312	.756
CH+RH	69.33 ± 7.91	70.02 ± 9.53	-.355	.723
	left handedness			
CH	8.41 ± 2.7	8.95 ± 2.84	-.616	.541
RH	55.96 ± 10.62	56.77 ± 10.26	-.247	.806
CH+RH	64.36 ± 12.04	65.72 ± 11.84	-.359	.722

CH: condylar height; RH: ramal height; CH+RH: total height; mm: millimeter; SD: standard deviation

Table 4 *Comparison of all measurements in the right handedness and left handedness*

Parameter	Hand preference	n	Mean (mm)	SD	min	max	p
right CH	right hand	41	8.13	1.75	4.10	13	.636
	left hand	20	8.4	3.7	4.9	14.9	
left CH	right hand	41	8.24	1.52	5.1	11.6	.309
	left hand	20	8.95	2.84	4.7	15.4	
right RH	right hand	41	61.2	7.78	47.60	79.10	.059
	left hand	20	55.96	10.62	42.7	75	
left RH	right hand	41	61.78	8.99	44.16	78.80	.56
	left hand	20	56.78	10.26	42.8	77.7	
right CH+RH	right hand	41	69.33	7.91	53.6	87.80	.132
	left hand	20	64.36	12.04	47.6	89.9	
left CH+RH	right hand	41	70.02	9.53	52.61	87.3	.590
	left hand	20	65.71	11.84	47.5	93.10	

CH: condylar height; RH: ramal height; CH+RH: total height; n: number of patients; mm: millimeter; SD: standard deviation; min: minimum; max: maximum

Table 5 *The relationships between the AI values and the hand use preference*

parameter	groups	mean(%)	SD	min	max	t	p
condylar AI	right handedness	7.23	5.9	0.54	25.15		
	left handedness	6.59	5.4	0.59	20.51	-.407	.686
ramal AI	right handedness	2.88	2	0.07	7.9		
	left handedness	2.39	2.24	0.08	9.4	-.852	.397
total AI	right handedness	2.36	1.73	0.29	6.8		
	left handedness	2.65	2.46	0.11	10.15	.542	.590

AI: asymmetry index; SD: standart deviation; min: minimum; max: maximum

4. DISCUSSION

Although hundreds of behavioral asymmetries have been identified as a result of hemispheric asymmetry, the most obvious one is hand preference (7). Most of right-handers are reported to be right-eyed and right-footed and they have their skills represented in the left cerebral hemisphere, whereas left-handers have less anatomical symmetry in the brain (9). Since it has been reported that hand preference may be associated with cerebral asymmetries and therefore with craniofacial asymmetries (6), it has been claimed in some studies that there may be a relationship between handedness and orthodontic anomalies such as facial asymmetry (4,8) and unilateral Angle Class II malocclusions (9). Facial asymmetries and orthodontic malocclusions were also related to condylar and ramal mandibular asymmetries (19,20). In the present study, it was aimed to evaluate the relationship between the condylar and ramal mandibular asymmetries and functional laterality, and hand preference.

Some researchers have criticized the use of questionnaires because their results have been found conflicting compared with direct observations. On the other hand; observational evaluations have also been reported to be unclear because manual functions can be learned equally with both hands (21). It has been shown that the determination of the dominant hands of the individuals with only one action (such as writing or observation) does not generally reflect the result; it is stated that the correct result is reached with the hand preference questionnaires (22,23) The most frequently used Oldfied questionnaire was preferred in the current study because it is simple, easy to understand, and suitable for all ages and the reliability of the questionnaire has also been demonstrated (24-26). According to this questionnaire hand use preference is grouped in three ways: right-handedness, left-handedness, and ambidextrous. Ambidextrous participants were excluded from the current study to be able to avoid bias in the results.

Such a consistent and strong preference for behavior on one side is unique to humans, though hand preference has been observed in some other primates (27). The factors that determine hand-use preference may be genetic or environmental (28). It has been reported that 90% of human subjects consistently choose their right hand for dexterous duties (29). Similar to the study Tan, 67.2% of the participants in the present study were determined as right-handed and 32.8% were left-handed (17).

AI formula was used in studies in which mandibular vertical asymmetry was found to be related to different malocclusion types such as unilateral crossbites (19), Angle Class II malocclusions (30), and temporomandibular disorders (31-33). To eliminate the effect of the relationship between the malocclusions and mandibular asymmetry; skeletal Class I and normodivergent patients were included in the present study.

Facial asymmetry has been accepted as an inherently occurring phenomenon in most subjects (13). While many researchers reported that the right side of the face is more developed than the left side (34,35), there are also studies claiming the opposite (4,8). In the present study mean CH, RH, and CH+ RH values were higher on the left side than the right side but this difference was also not significant.

It was suggested that an asymmetric development of brain regions related to functional laterality may cause the

asymmetric development of facial regions (4). Smith reported that cognitive duties that involve one hemisphere more than the other may result in higher muscle size and activity, on the side of the face which is controlled by that hemisphere (35). Besides, right-handedness was associated with a greater ethmoid roof on the left side and a larger left side of the brain (4,8,36). Keleş et al concluded that facial areas on the left were significantly larger than those on the right in right-handers and the left-handers tended to have larger facial areas on the right (4). Parallel to that findings; the left facial region was found larger for right-handers than left-handers (8). Gary et al. investigated the frequency of left-handedness in patients with hemifacial microsomia in which the predominant side of involvement was right in 49 % (10). They reported that patients with hemifacial microsomia were more likely to be left-handed compared with the control group and also they concluded that hemifacial microsomia affects cerebral lateralization (10). According to all these findings, it is obvious that handedness is associated with facial asymmetry. The mandibular asymmetry which is maybe the primary reason for facial asymmetry (37) directly affects the facial appearance (38). In the present study, CH, RH, and CH+RH values measured on the left side were higher than on the right side on both right-handed and left-handed participants; but this result was not statistically significant for all parameters in both groups. Mandibular asymmetry indices were also statistically similar to right-handed and left-handed participants. This finding was parallel to Hujoel et al.'s study in which the authors concluded that lower face asymmetries were not associated with heritable features (1). Mandibular asymmetry can be caused by functional factors as well as morphological or genetic disorders (39-41). The asymmetric function and activity of the jaws may cause different development of the left and right parts of the mandible (20,42,43). Since malocclusions or functional disorders that may cause mandibular asymmetry were eliminated during the sample selection of the current study, it can be concluded that hand preference, which is a marker of functional laterality, alone did not affect mandibular asymmetry.

The current study has some limitations. First; the small left-handed sample size may be a limitation, but considering the finding that 90% of the society tends to be right-handed (44,45) the small number of left-handed participants in such retrospective evaluation is an expected situation. The method for determining the hand-use preference of the participants may be another limitation of the study. Although the questionnaires were accepted as reliable methods, their use with observational evaluations may yield more reliable results (23,24).

5. CONCLUSIONS

Condylar, ramal, and total mandibular height measurements for the left and right sides of the mandibula were similar in the skeletal Class 1, normodivergent study group. Hand use preference was not associated with condylar, ramal, and total mandibular asymmetry. Longer-term studies in which hand use preference and mandibular asymmetry were also observed clinically may support the results of the present study.

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