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SOFT TISSUE CEPHALOMETRIC ANALYSIS OF MALAY ORTHODONTIC PATIENTS

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ABSTRACT

Soft tissue analysis plays a very important role in orthodontics where it aids in the diagnosis, treatment planning, improve treatment success and establish optimal facial harmony. The soft tissues are a major factor in determining the external facial appearance. The establishment of Holdaway analysis among Malay patient would further aid our understanding on Malay patient's soft tissue profile. The aim of this study was to evaluate soft tissue measurements for a Malay sample population using Holdaway's analysis. We also compared our soft tissue findings and the patients' respective skeletal patterns. Cephalometric radiographs of 62 Malay female adult patients aged 18 to 40 years old who attended Orthodontic Specialist Clinic, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Malaysia were traced and evaluated. Cephalometric landmarks were located according to Holdaway analysis. Nine linear and two angular measurements were produced on each radiograph. The results suggested that, the soft tissue measurements for the Malay females were different to that of the Holdaway norms, except for the soft tissue facial angle, upper lip curvature, and nose prominence, whilst the other measurements were larger than the Holdaway averages. The Malay female sample had pronounced convexity soft tissue facial profile, as well as deeper superior and inferior sulci, and thicker soft tissue chins than the Holdaway values. To conclude, the normal values of Holdaway soft tissue analysis for the Malay female adults were established for use in orthodontic practices in this population.

KEYWORDS: ***Holdaway analysis, Malay patients, Soft tissue, Lateral cephalometric radiographs***

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INTRODUCTION

In orthodontics, much attention has been devoted to facial esthetics, balance and harmony. It is presumed that optimal facial harmony indicates well-defined underlying skeletal and dental structures [1]. Soft tissue analysis plays a very important role in orthodontics where it aids in the diagnosis, treatment planning, improve treatment success, and in establishing optimal facial harmony. The soft tissues are a major factor in determining a patient's external facial appearance. Several investigators have observed that soft tissue behaves independently from the underlying skeleton because the soft tissue covering the teeth and the skeletal face are highly variable in their thickness [2]. The successful treatment planning for orthodontic treatment should involve both hard and soft tissue cephalometric analysis. The importance of soft tissue and facial esthetics relation in orthodontic treatment was emphasized by Angle as early as 1907 [3]. He pointed out that the soft tissues were an important factor in facial harmony. The study conducted by Holdaway [4] found that the treatment goals were much improved when soft tissue features were considered during treatment planning. Furthermore, the soft tissue profile analysis plays an important role in evaluating a patient's final facial profile. Several researchers pointed out that the soft tissue relationships might contribute to or detract from facial harmony and to explain how the soft tissue analysis could be used in orthodontic treatment planning [5]. Legan & Burstone [6] and Holdaway [7] helped in progressing soft-tissue analysis that achieved wide acceptance in clinical and research work in both orthodontics and orthognathic surgery. In recent literature, there has been an increased emphasis on soft tissue, both in diagnosis and treatment results. Several studies have been performed to set values and norms for harmonious facial soft tissue, and the results have stressed the importance of soft tissue in the diagnoses [4, 8, 9-23]. Knowledge of the normal dentofacial pattern and its overlying soft tissue helps in the advancements of treatment success and construction of optimal facial harmony. This has led to the introduction of importance of soft tissue analysis in orthodontic treatment. Holdaway soft tissue analysis has been adapted in most cephalometric studies to understand soft tissue characteristic in different population or ethnicities. However, there is no established Holdaway analysis amongst Malay patients that can be used to understand the Malay patient's soft tissue profile. The aims of this study were to evaluate soft tissue measurements for a Malay sample population using Holdaway's analysis, and to compare the relationship between the soft tissue findings and the patients' respective skeletal patterns.

MATERIALS AND METHODS

Sixty-two Malay female adult patients who attended Orthodontic Specialist Clinic at Advanced Medical and Dental Institute, Universiti Sains Malaysia, Malaysia aged 18 to 40 years old were included in the study as they fulfilled the inclusion criteria. Among other inclusion criterias that has been determined for this study were:

- All patients had Malay parents based on interview.
- No history of facial trauma.
- Free from congenital or craniofacial abnormalities.
- No symptoms related to temporomandibualr joint disorder.
- No prior plastic surgery history.

Pre treatment lateral cephalograms of the patients which were obtained during their orthodontic treatment were retrieved from their records. All 62 patients who participated in this study provided informed consent. All procedures performed in this study involving human participants were in accordance with the ethical standards of the Universiti Sains Malaysia (JEPeM code USM/JEPeM/16110525). The eleven parameters in Holdaway analysis were automatically calculated using Planmeca Romexis® Cephalometric Analysis software program once the anatomical points have been digitized for each lateral cephalogram. Landmarks and reference lines of Holdaway [4] were used. Each of the radiographs was calibrated digitally prior to commencing digital tracing.

Measurements used in the study

Skeletal measurements used in the study

To assess the skeletal analysis, the skeletal classes were classified as the following based on Jacobson [1].

- Class I: ANB angle is (2˚-4˚).
- Class II: ANB angle > (2˚-4˚).
- Class III: ANB angle < (2˚-4˚).

Where, A is the greatest concavity point on the line between the prosthion and the anterior nasal spine, B is the greatest concavity point on the line between the infradentale (apex of the alveolar bone between the left and right lower first incisors) and pogonion, and N is the Nasion, which is the greatest concavity point in the midline between the nose and the forehead on the frontonasal suture. SNA is the angle related to the anteroposterior position of the maxilla to the cranial base and it angle connects three anatomical structures in the lateral cephalogram which is the S (Sella turcica), N (Nasion) and A (A point). The SNB is the angle related to the anteroposterior position of the mandible to the cranial base and it connects three anatomical structures in the lateral cephalogram which is the S (Sella turcica), N (Nasion) and B (B point). ANB is the angle related to the anteroposterior position of the mandible to the maxilla and can be determined the skeletal class by calculating the difference between SNA and SNB. If the ANB angle is between 2˚- 4˚ (within normal range), the skeletal pattern is considered as skeletal Class I. If this angle is less than normal range, it is Class III and if it is more than normal, it is Class II skeletal pattern.

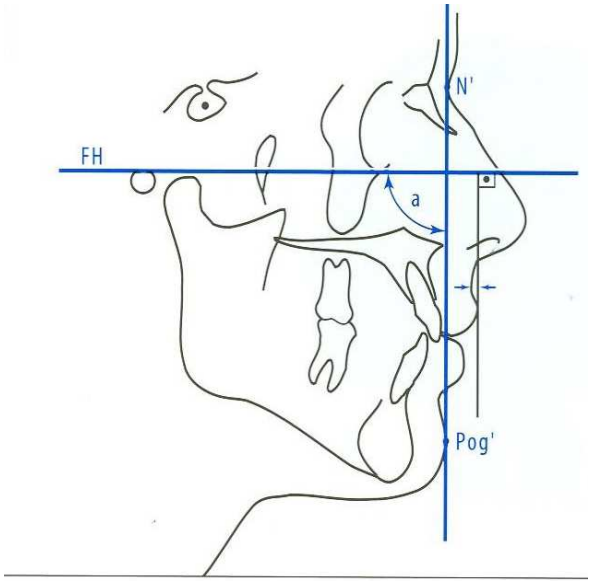
Soft tissue measurements used in the study (Holdaway analysis measurement method)[1]

Measurement of the eleven parameters can be explained as:

Angular measurements

Soft tissue facial angle (Figure 1)

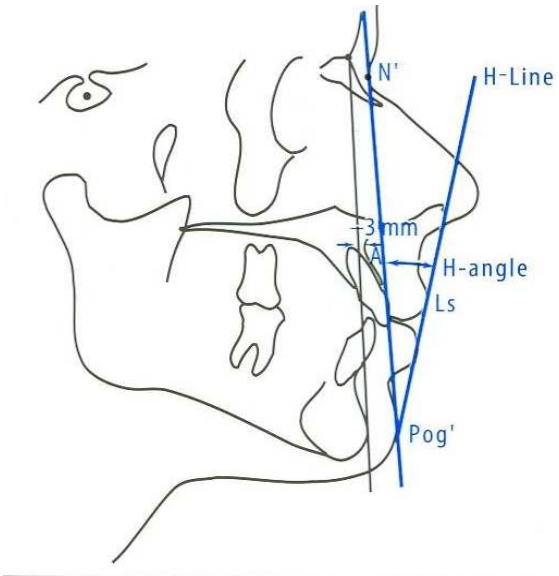
Angle constructed by intersecting a line extended from N' to pog' with FH. Ideally, this angle should be 90˚ to 92˚. A greater angle suggests a mandible that is too protrusive; an angle that is less than 90˚ suggests a recessive lower jaw.



The facial angle (a) is formed by the intersection of FH and a line connecting N' and Pog'. Ideal values are 90˚ to 92˚. Upper lip curvature is defined as the depth of the sulcus from a line drawn perpendicular to FH and tangent to Ls (ideal value, 2.5 mm)

Figure 1
Facial angle and upper lip curvature[1]

H angle (Figure 2)
The H-line is tangent to Me' and Ls. The H angle established between the soft tissue N'-Pog' line and H-line. This angle gives an idea about the upper lip prominence or the soft tissue chin retrognathism. The degree of skeletal convexity (measured at point A) will cause the H-line angle to vary. Concave, straight, or convex profiles may have soft tissue that is in balance and harmony. However, these faces demonstrate a relationship between the H-line angle and skeletal convexity at point A. The best range is from 7˚ to 15˚.



The H-line angle is formed by the intersection of N' and Pog' line and a line tangent to Pog' and Ls. The latter line is also known as the H-line

Figure 2
Skeletal convexity at point A and Holdaway's H-line angle[1]

Linear measurements
Upper lip curvature (Figure 1)
A perpendicular is dropped from FH tangent to Ls. From this line, the depth of the upper lip sulcus is measured. Ideally, it should measure 2.5 mm in patients with lips of average thickness. In individuals with thin or thick lips, a thickness of 1.5 mm and 4.0 mm, respectively, is acceptable. Lack of upper lip curvature is suggestive of lip strain. Excessive depth could be caused by lip redundancy or jaw over closure.

Skeletal profile convexity (Skeletal convexity at point A) (Figure 2)
Skeletal convexity can be measured from the skeletal nasion-pogonion (N-Pog) line to point A. This is not a soft tissue measurement, but a good parameter to evaluate facial skeletal convexity relating to lip posture. The measurement, which extends from -2 mm to 2 mm, dictates the dental relationships needed to produce facial harmony.

Nose prominence (Pn to H line) (Figure 3)
This measurement should not exceed 12 mm in individuals 14 years of age and older. Although nose size is important to facial balance, lip balance and harmony, in general contribute more to the total picture of facial balance.

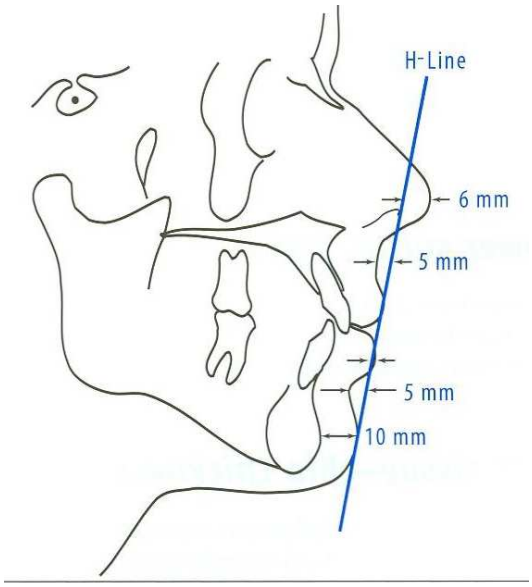


Figure 3
Pn to H-line, upper sulcus depth, Li to H-line, lower sulcus depth and soft tissue chin thickness[1]

Upper sulcus depth (Figure 3)
The upper sulcus depth is measured from the H-line. The upper lip is in balance when this measurement around 5 mm. A measurement of 3 mm may be adequate with short and/or thin lips. In longer and/or thicker lipped individuals, a measurement of 7 mm may still indicate excellent balance. It is importance to read this measurement together with the upper lip curvature measurement.

Lower lip to H-line (Li to H-line) (Figure 3)
The Li to H-line is measured from the most prominent outline for the lower lip. A positive reading denotes that the lips are in front of the H-line, and a negative reading denotes that the lips are behind this line. The normal range is -1 mm to +2 mm.

Inferior sulcus to H-line (Lower sulcus depth) (Figure 3)
The lower sulcus depth is measured at the point of deepest curvature between the chin and the lower lip. A measurement of 5 mm is ideal.

Soft tissue chin thickness (Figure 3)
It is measured as the distance between the soft tissue and the bony chin (i.e., hard tissue Pog to soft tissue Pog'). A distance of 10 mm to 12 mm is ideal. In very fleshy chins, the mandibular incisors may be permitted to remain in a more prominent position to allow for facial harmony.

Upper lip thickness (Figure 4)
It can be measured horizontally from a point on the outer alveolar plate 2 mm below point A to the outer border of the upper lip. At this point, nasal structure will not impact the lip drape. The normal upper lip thickness is 15 mm.

Upper lip strain (Figure 4)
The upper lip strain can be measured horizontally from the labial surface of the maxillary central incisor to the vermilion border of the upper lip. This measurement should be around the same as the thickness of the upper lip (within 1 mm). If thickness of the upper lip is more than this measurement, the lips are called strained. For example, if the thickness of the upper lip is 14 mm and the thickness between vermillion border and the maxillary incisor is 7 mm, the difference between the two measurements (14 mm and 7 mm) would reflect a lip strain factor of 6 mm or 7 mm. In other words, the incisors would have to be retracted to be approximate 7 mm to reach the point at which the lips assume normal from the thickness. Should further tooth movement be required, the lips would not follow the teeth. Thick lips do not always follow tooth movement, whereas thin lips adapt more closely to such changes.

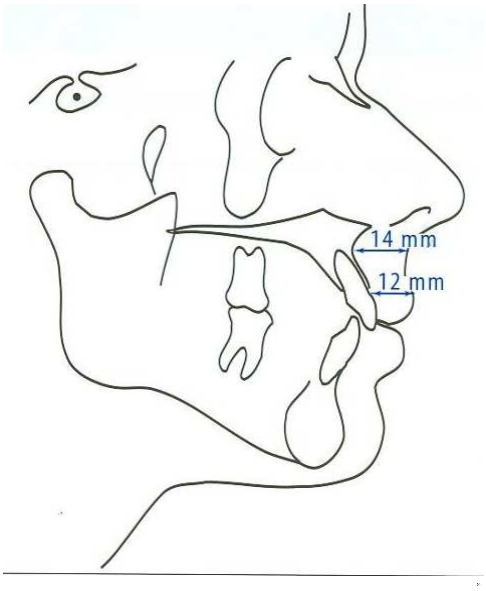


Figure 4
***Upper lip thickness and upper lip strain*[1]**

Cephalometric landmarks used in the study

For each lateral cephalogram, the following landmarks were identified according to Jacobson [1].

Hard tissue and dental points

Sella turcica (S), Nasion (N), Porion (Po), Orbitale (Or), Point A, Labial outline of upper incisor (+1L), and Pogonion (Pog) (Fig 5).

Soft tissue landmarks

Soft tissue Nasion (N'), Pronasale (Pn), Subnasale (Sn), Labrale Superius (Ls), Labrale Inferius (Li), Soft tissue Point A, Soft tissue Point B and Soft tissue Pogonion (Pog') (Fig 5).

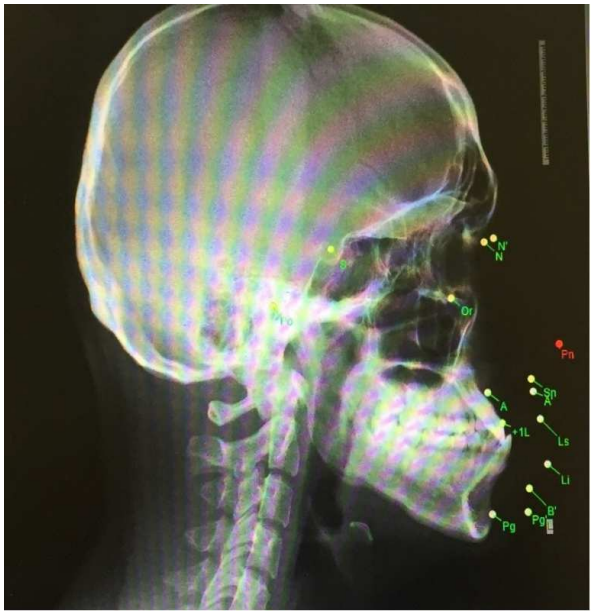


Figure 5
Hard and soft tissue cephalometric landmarks used in digitization

Sample size calculation

Sample size calculation was done using a software program Power and Sample Size Calculations (PS), Version 3.0 [24]. For the first objective, whereby the soft tissue measurements for a Malay sample population shall be compared with Holdaway analysis average norms. The sample size calculation was performed using the above-mentioned software program. In a previous study the response within each subject group was normally distributed with standard deviation 1.5 [10] and the true difference in the means was 1.0. We needed to study 48 experimental subjects to be able to reject the null hypothesis that the population means of the tested groups are equal with probability (power) 0.9. The type I error probability associated with this test of this null hypothesis is 0.05. For the second objective, whereby the relationship between the soft tissue findings and the patients' respective skeletal patterns three independent groups (soft tissue analysis for skeletal pattern I (0), II (44) and III (18)) mean value are being statistically compared to detect significance difference. The sample size calculation was obtained using the

same software program. In a previous study the response within each subject group was normally distributed with standard deviation 1.5 [10] and the true difference in the means was 1.0. We need to study a minimum of 26 patients per group to be able to refuse the null hypothesis that the population means of the tested groups are equivalent with probability (power) 0.9. The type I error probability correlated with this test of this null hypothesis is 0.05.

Statistical Analysis

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) software version *22 (USA).* Descriptive statistics were calculated for each variable including standard deviations (SD) and means. To test the intra examiner reliability, 20 lateral cephalograms were randomly selected from the sample to find the errors correlated with radiographs tracing and measurements. The measurements and tracings were repeated two weeks after the first measurements. A paired *t*-test was performed to the first and second measurements [18]. The difference between the first and second measurements of the 20 radiographs was insignificant. Correlation analysis applied to the same measurements showed moderate to strong correlation with Pearson correlation value of 0.5 and above. An independent Student's *t*-test was used to study the difference between the soft tissue findings and the patients' respective skeletal patterns. The level of significance was set as $p \leq 0.05$.

RESULTS

Holdaway norms, means, and standard deviations for the Malay female adults are given in Table 1. The results showed that the following parameters, including facial angle, upper lip curvature, and nose prominence to H line had No statistically significant different between the Holdaway norm and the Malay population value, while the following parameters, including skeletal convexity at point A, H angle, upper lip thickness, upper lip strain, lower lip to H-line, lower sulcus depth, upper sulcus depth, and soft tissue chin thickness showed statistically significant difference between the Holdaway norm and the Malay population value since the *p*-value was less than 0.05. Table 2 shows the descriptive statistics difference between the soft tissue findings and the patients' respective skeletal patterns. The results showed that the facial angle parameter and H angle parameter were statistically significantly different between the skeletal Class II and the skeletal Class III and the other parameters did not show any statistically significant difference.

Table 1
The difference in soft tissue parameters between Malay population value and Holdaway norm

Parameters	Mean ±S.D (Holdaway norm)	Mean ±S.D (Malay population value)	Mean differences	*t*-statistic	*p*-value
Soft tissue facial angle (˚)	91.0 ± 5.00	91.3 ± 4.04	-0.32	0.63	0.52
Upper lip curvature (mm)	2.50 ± 0.01	2.54 ± 2.00	-0.04	-0.81	0.42
Skeletal profile convexity (mm)	0.00 ± 3.57	2.49 ± 1.98	-2.49	6.36	0.001*
H angle (˚)	10.0 ± 3.48	14.6 ± 3.22	-4.69	11.6	0.001*
Nose prominence to H line (mm)	14-24 ± 3.67	18.5 ± 3.28	-4.51	0.09	0.92
Upper sulcus depth (mm)	3.00 ± 3.82	3.10 ± 1.74	-0.10	1.99	0.001*
Upper lip thickness (mm)	13-14 ± 5.76	12.6 ± 0.63	0.32	-6.90	0.001*
Upper lip strain (mm)	15.0 ± 3.78	14.0 ± 1.92	1.00	-8.41	0.001*
Lower lip to H-line (mm)	0.50 ± 3.05	1.65 ± 1.94	-1.65	5.94	0.001*
Lower sulcus depth (mm)	5.00 ± 3.83	4.88 ± 2.91	0.12	6.28	0.001*
Soft tissue chin thickness (mm)	10-12 ± 3.24	13.1 ± 3.79	-3.10	2.06	0.04*

* Significant *p*-value.

Table 2
The difference in soft tissue parameters between the skeletal Class II and the skeletal Class III patterns[1]

Parameters	Mean ±S.D (Skeletal Class II)	Mean ±S.D (Skeletal Class III)	Mean differences	*t*-statistic	*p*-value
Soft tissue facial angle (˚)	90.3 ± 3.60	93.7 ± 4.11	-3.40	-3.21	0.02*
Upper lip curvature (mm)	2.33 ± 1.77	3.19 ± 2.34	-0.86	-1.56	0.12
Skeletal profile convexity (mm)	58.3 ± 75.6	43.7 ± 28.4	14.6	0.79	0.43
H angle (˚)	20.5 ± 4.48	14.6 ± 4.91	5.89	4.56	0.001*
Nose prominence to H line (mm)	12.8 ± 48.7	11.5 ± 14.3	1.26	0.10	0.91
Upper sulcus depth (mm)	8.78 ± 41.7	4.54 ± 13.7	4.24	0.41	0.67
Upper lip thickness (mm)	8.11 ± 7.36	9.90 ± 7.47	-1.79	-0.86	0.39
Upper lip strain (mm)	6.35 ± 10.0	3.34 ± 5.04	3.01	1.20	0.23

Lower lip to H-line (mm)	13.8 ± 18.0	12.9 ± 15.9	0.95	0.19	0.84
Lower sulcus depth (mm)	8.74 ± 17.8	8.77 ± 15.6	-0.03	-0.01	0.99
Soft tissue chin thickness (mm)	16.0 ± 18.4	12.8 ± 2.69	3.25	0.73	0.46

***** Significant *p*-value.

DISCUSSION

This is the first study that is performed to determine the significance of Holdaway soft tissue analysis of the Malay female adult patients who sought for orthodontic treatment. Moreover, this study also found that there was not much reported data on soft tissue findings in Malay ethnicity. Although considerable data have been collected for Malaysian adults Chinese [22], Malaysian adults Indians [25], Turks [11], Saudian Arabs [20], Palestinian Arabs [18], Bangladeshi [21], Southern Rajasthan [23], Asians, and Europeans [9], and Americans [26], there are no accumulated data to create criteria for the Malay soft tissue cephalometric measurements. In this study, soft tissue analysis was performed according to Holdaway's recommendations to determine facial aesthetic and harmonious values. His observation considered that the soft tissue measurements do not always follow hard tissue measurements [4]. Soft tissue components that were important to facial esthetics were measured in this study. Linear as well as angular measurements were computed. More than one measurement denoting the same craniofacial region was used to allow for proper presentation of each area measured. Comparing the soft tissue variables of Malay female adults and Holdaway norms, we observed that certain parameters were found to be similar in some readings but significantly different in other readings between variables. Reported Yemeni [13] and Japanese [8] values for the soft tissue facial angle are close observed here for the Malay female sample. In contrast, the mean value reported for Anatolian Turkish adults [11] is about 4˚ smaller, indicating a more convex profile for the Turks. The depth of the lower lip sulcus was similar among Malay females, Turkish Anatolian [11], Yemeni population [13], and Palestinian population [18], however was deeper in the Japanese population [8]. The H angle appeared higher in Malay female sample than that recommended by Holdaway, indicating a convex profile for the Malay females, whereas European Americans [26] showed a smaller H angle than the Malay females. Anatolian Turks [13] showed a slightly smaller value than our sample, whereas the Japanese [8] showed a slightly larger value. Yemeni [13] and Korean adults [9] exhibited higher values than the Malay female sample. The prominence of the nose had a smaller range in our sample than that accepted by Holdaway. Similar values have been reported for Anatolian Turks [11]. The skeletal profile convexity measurement in the Malay female sample was larger than that of Holdaway and the Turkish Anatolians, however smaller than that of Japanese and Yemeni populations. The thickness and strain of the upper lip in the Malay female sample was close to that of Holdaway, although the range of the Malay female sample was smaller. European American [19] and South Indian [14] populations have reported similar basic upper lip thickness to those reported here, whereas a Yemeni subjects [13] exhibited a higher average thickness. The lower lip in our Malay female sample was more posteriorly positioned relative to the H line than that was reported by Holdaway. This result is similar to that was reported for Yemeni [13], Japanese [8], and Korean adults [9], however larger than that reported for Turkish Anatolian [11] and European Americans [9]. The increased distance between the lower lip and H line may indicate a prominent chin or retruded lip. The upper lip curvature showed no significant differences. This finding corresponded with Scheideman et al [27] for Caucasian subjects, Miyajima et al [28] for Japanese subjects and Al-Humam [29] for Yemeni subjects. However, this finding disagrees with Al Barakati and Bindayel [20] for Saudi subjects who found that nasolabial angle greater in females. This disagreement may be due to the different ethnicity in each of the studied population. The value of the soft tissue chin thickness in the Malay female sample was close to that recommended by Holdaway, with a wider normal range. Similar values have been reported for Yemeni [13] and South Indian adults [14], however slightly higher values have been reported for Turkish Anatolian [11] and Japanese [8]. Differences between the different populations in the soft tissue norms could be attributed to several factors, including different ethnic backgrounds, selected sample size, and age of the studied population. We conclude that our findings should be considered during orthodontic treatment planning of Malay patients, especially before deciding to extract teeth for orthodontic treatment.

Limitations of the study

Regarding the use of Malay female patients alone was a challenge for us to obtain lateral cephalograms of male patients. Only ten lateral cephalograms of male patients were found to be suitable, thus we decided to carry on with the soft tissue analysis using female lateral cephalograms alone. The data collection was from patients attending Orthodontic Specialist Clinic at Advanced Medical and Dental Institute, Universiti Sains Malaysia, Malaysia for orthodontic treatment. This could affect the sample selection, as the sample might not represent the non treated population.

CONCLUSIONS

We determined normal values for the Holdaway soft tissue analysis for Malay female adults, which were different than the Holdaway norms. Malay females had pronounced convexity soft tissue facial profile, as well as deeper superior and inferior sulci, and thicker soft tissue chins than the Holdaway values. Authors established Holdaway analysis amongst Malay patients that can be used to understand the Malay patient's soft tissue profile that would help in better orthodontic diagnosis and treatment planning.

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AUTHORS' CONTRIBUTIONS

Dr. Yahya H. Y. Alfarra designed the research, collected the data, performed the measurements and drafted the manuscript. Dr. Khoirulzariah Ismail and Dr. Anis Farhan Kamaruddin were involved in planning and supervised the work. Dr. Yahya H. Y. Alfarra took the lead in writing the manuscript. Dr. Khoirulzariah Ismail aided in interpreting the results. All authors reviewed and approved the final manuscript.

CONFLICTS OF INTEREST

Conflicts of interest declared none.

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