Comparisons of soft tissue chin thickness in adult patients with various mandibular divergence patterns

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ABSTRACT

Objective: To evaluate the association between soft tissue at the chin (STC) thickness and mandibular divergence.

Materials and Methods: Nongrowing patients seeking orthodontic treatment (n = 190; 113 women and 77 men), who had an average age of 26.94 years (range = 18.10–53.50 years), were stratified in four subgroups based on cephalometric mandibular plane inclination to anterior cranial base (MP/SN): low = MP/SN $\leq 27^\circ$ (n = 48); medium-low = $27^\circ <$ MP/SN $\leq 32^\circ$ (n = 60); medium-high = $32^\circ <$ MP/SN $< 37^\circ$ (n = 37); and high = MP/SN $\geq 37^\circ$ (n = 45). The STC thicknesses were measured at pogonion (Pog), gnathion (Gn), and menton (Me). Group differences were evaluated with two-way analysis of variance and Student's *t*-test. The Pearson product moment correlation gauged associations between parameters.

Results: The STC values were greater in men than women ($P < .02$) and were smaller in the high group (7.47 $\pm$ 2.42 mm) than in all other groups at Gn (mean values = 9.00 mm < STC < 9.58 mm; $P < .001$) and at Me (high group = 6.30 $\pm$ 1.89 mm; other groups = 7.15 mm < STC< 7.57 mm; $P = .011$).

Conclusion: The STC is thinner at Gn and Me in hyperdivergent facial patterns, apparently in contrast to Pog. This differential thickness warrants focused research as it implies that it is possible (1) to vertically grow hard tissues impinging on the inferior soft tissue envelope in patients with severe hyperdivergence and (2) to plan for genioplasty in such patients when more advancement of the chin might be needed to compensate for the increased vertical height. (*Angle Orthod.* 2014;84:708–714.)

KEY WORDS: Chin; Soft tissue; Divergence; Mandible; Adult; Thickness

INTRODUCTION

The vertical dimension influences orthodontic diagnosis and treatment planning in growing and adult patients.[1,2] Two commonly used measurements have emerged to aid in determining the vertical facial type[3] in relation to underlying skeletal features: inclination of the mandible to the anterior cranial base or to the maxilla and percentage of lower to total facial height.

The covering facial soft tissues (muscles, fat, skin) can develop in proportion or disproportion to the corresponding skeletal structures.[4] Variations in thickness, length, and tonicity of the soft tissues may affect the position of and the relationships among the facial structures thereby affecting facial esthetics.[5] Such variations between skeletal and soft tissues can cause a disassociation between the position of the underlying bony structures and the facial appearance that may shift treatment into the range of orthognathic and cosmetic surgery. In the orthodontic literature, minimal attention has been dedicated to the role of soft tissue characteristics in establishing optimal diagnosis and treatment plan. Most studies of facial soft tissue concerned changes after orthodontic treatment.[6,7]

The need for orthognathic surgery in combination with orthodontic treatment in adult patients has yielded

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Table 1. Descriptive Statistics[a]

		Groups				
	Total	Low, MP/SN $\leq$ 27°	Medium-Low, 27° $<$ MP/SN $\leq$ 32°	Medium-High, 32° $<$ MP/SN $<$ 37°	High, MP/SN $\leq$ 37°	*P* [b]
Total sample						
N	190	48	60	37	45	
Age, y (range)	26.94 (18.10–53.50)	27.96 (18.70–53.50)	25.72 (18.10–45.50)	28.44 (18.10–49.60)	26.24 (18.10–50.40)	NS
Men						
N	77	20	27	15	15	
Age, y (range)	26.74 (18.10–53.50)	29.81 (18.80–53.50)	25.08 (18.10–45.00)	25.81 (18.30–49.60)	26.56 (18.80–45.10)	NS
Women						
N	113	28	33	22	30	
Age, y (range)	27.08 (18.10–50.40)	26.65 (18.70–50.10)	26.24 (18.70–45.50)	30.23 (18.10–48.60)	26.06 (18.11–50.40)	NS
P [c]	NS	NS	NS	NS	NS	

[a] MP/SN indicates mandibular plane to anterior cranial base; NS, not significant.
[b] Statistically significant differences for age across groups (low-high).
[c] Statistically significant differences for age between men and women within each group.

important information regarding the relation between soft and hard tissues. Genioplasty, indicated to restore adequate shape and projection of the chin in the face, has been performed to enhance soft tissue contours related to disproportion between soft and hard tissue and has produced stable long-term postsurgical changes.[8] High correspondence of soft tissue changes at the chin level has been reported after advancement genioplasty, resulting in a ratio of bony tissue to soft tissue ranging from 1:0.75 to 1:0.92.[9,10]

We observed deficient chin appearance in patients with hyperdivergent mandibular pattern that required advancement genioplasty with the required jaw movements. In contrast, genioplasty was not needed in patients with hypodivergent mandibles. Thickness of the soft tissue at the chin (STC) has been correlated mostly with discrepancies in the sagittal plane.[11] In a study of the association between STC thickness and vertical divergence, the focus was limited only to the correspondence of hard and soft tissue pogonion (Pog), neglecting the angle of the chin and its inferior part.[12]

The aims of this study were to evaluate in the following in adult patients: (1) the association between mandibular divergence and STC thickness measured at different chin levels and (2) the difference in STC thickness between men and women.

MATERIALS AND METHODS

Based on the inclusion criteria, the material comprised 190 pretreatment lateral cephalograms of white adult subjects (77 men and 113 women). Mean age was 26.94 years (range = 18.10–53.50 years) (Table 1). Before the study was conducted, signed consent to use the radiographs was obtained from the patients. The inclusion criteria were age above 18 years, lateral cephalogram taken at rest with no lip strain, and well-defined and identifiable chin structures on the radiograph. Exclusion criteria were previous orthodontic and/or orthognathic surgery treatment, presence of craniofacial anomaly, or presence of a noncontinuous soft tissue contour at the level of the chin indicating a chin strain.

The lateral cephalometric radiographs were taken using the same digital cephalostat (GE, Instrumentarium, Tuusula, Finland) in a standardized method and in a natural head position.[13] Angular measurements were computed to determine the vertical position of the maxilla and mandible in relation to the anterior cranial base, to true horizontal, and to each other (Figure 1). The angles included palatal plane to mandibular plane (PP/MP), palatal plane to horizontal (PP/H), mandibular plane to horizontal (MP/H), and mandibular plane to anterior cranial base (MP/SN). The sagittal relationship between the jaws was assessed by the ANB angle. The STC thickness was measured at three different levels (Figure 1): (1) Pog-Pog'= length between bony pogonion (Pog) and its horizontal projection (Pog') over the vertical passing through soft tissue pogonion; (2) Gn-Gn'= distance between bony gnathion (Gn) and soft tissue gnathion (Gn'); and (3) Me-Me'= distance between bony menton (Me) and its vertical projection (Me') on the horizontal passing through soft tissue menton. The three distances were measured using CliniView Dental Imaging software provided by the cephalostat manufacturer.

To determine the intraobserver reliability, a single investigator repeated all angular and linear cephalometric measurements on 20 randomly selected cephalographs (nearly 10% of the sample).

Patients were stratified into four groups based on the divergence pattern defined by the mandibular plane to cranial base angle (MP/SN; average = 32° ±

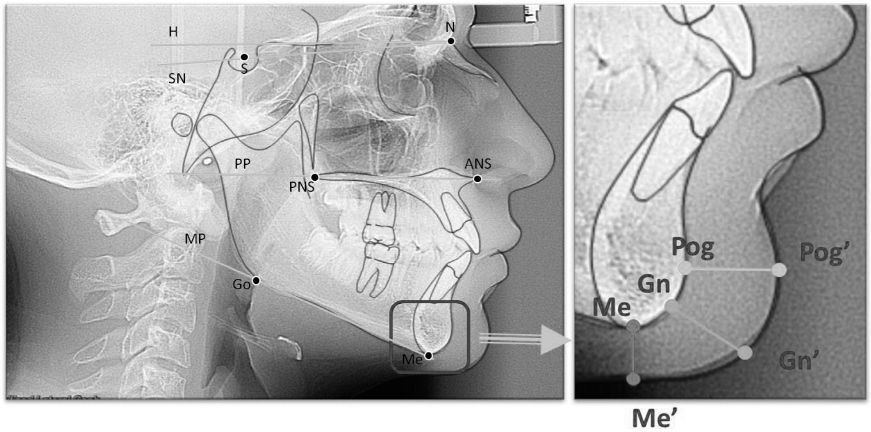

Figure 1. To the left, lateral cephalogram studied angular measurements: Mandibular plane (menton-gonion); palatal plane (anterior nasal spine-posterior nasal spine); sella-nasion angle; true horizontal. To the right, measurements of skin thickness at the chin were evaluated: hard tissue pogonion and the distance to its horizontal projection on the soft tissue (Pog-Pog'), distance from hard tissue gnathion to soft tissue gnathion (Gn-Gn'), and the distance from hard tissue menton to its vertical projection on the soft tissue (Me-Me').

5°)[3,14]: low (L) = MP/SN $\leq$ 27° (n = 48; 20 men, 28 women); medium-low (ML) = 27° $<$ MP/SN $\leq$ 32° (n = 60; 27 men, 33 women); medium-high (MH) = 32° $<$ MP/SN $<$ 37° (n = 37; 15 men, 22 women); and high (H), that is, the group with the severest hyperdivergent pattern, MP/SN $\geq$ 37° (n = 45; 15 men, 30 women) (Table 1).

Statistical Methods

The intraclass correlation coefficient helped determine examiner variability of repeated measurements. Two-way analysis of variance and post-hoc test (Bonferroni) were used for multiple comparisons (cephalometric angular and STC measurements) among the four groups. Age difference between genders in the total sample was evaluated with the Student's *t*-test. Kruskal-Wallis one-way analysis of variance was used to compare the studied parameters in men and women separately among the four groups; comparison of differences between genders within each group was achieved with the Mann-Whitney test. The Pearson correlation coefficient gauged the relationship between STC measurements and mandibular divergence angle. Statistical significance was set at P = .05. SPSS software (Chicago, IL), version 20.0 was used for statistical computation.

RESULTS

The intraclass correlation coefficients for the intraexaminer repeated measurements were high for all measurements ($0.993 < r < 0.997$).

Age was not statistically significantly different for men or women across the four groups (Table 1) or between men and women within each of the four groups (Table 1).

All groups had corresponding vertical cephalometric measurements (PP/H, MP/H, MP/SN) compatible with the degree of mandibular divergence initially stratified on MP/SN. These measurements were statistically significantly different among the groups (P = .022–0.001) except for PP/H in comparison between groups L-ML, ML-H, and MH-H (Table 2). The ANB angle was not statistically significant among the four groups (Table 2).

All STC thicknesses had the highest measurements in the hypodivergent group L and gradually decreased across the groups, the lowest being in the hyperdivergent group H (Table 2). At the level of Gn, the distance Gn-Gn' (group L = 9.58 $\pm$ 2.19 mm; group ML = 9.28 $\pm$ 2.43 mm; group MH = 9.00 $\pm$ 2.97 mm; group H = 7.47 $\pm$ 2.42 mm) was statistically significantly different between groups L-H, ML-H, and MH-H (P = .001–.039). At the level of Me, Me-Me' (group L = 7.57 $\pm$ 1.72 mm; group ML = 7.22 $\pm$ 1.96 mm; group MH = 7.15 $\pm$ 1.85 mm; group H = 6.30 $\pm$ 1.89 mm) was statistically significantly different only between the two extreme groups L and H (P = .008). No statistically significant difference existed at the level of Pog (Pog-Pog') among the groups.

Chin measurements (Table 3) were statistically significantly greater (P = .0001–0.03) in men than in women across all groups, except for group H of severe hyperdivergent pattern. Upon comparisons within male and female groupings separately, statistically significant differences were found at the level of Gn thickness in both genders, but post hoc test showed statistically significant differences only between the extreme groups L-H and ML-H in men (P = .022–0.039) and between groups L-H in women (P = .036).

Statistically significant correlations between STC thickness and cephalometric measurements were negative and in a low range: $r = -0.231$, $r = -0.315$,

Table 2. Means of Age, Selected Cephalometric, and Soft Tissue at the Chin Measurements in Groups Stratified on MP/SN[a]

Groups	Low, MP/SN ≤ 27°		Medium-Low, 27° < MP/SN ≤ 32°		Medium-High, 32° < MP/SN < 37°		High, MP/SN ≤ 37°		ANOVA	Comparisons Among Groups (*P*)					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	(*P*)	L-ML	L-MH	L-H	ML-MH	ML-H	MH-H
Age, y	27.96	9.19	25.72	7.02	28.44	9.51	26.24	8.33	NS	NS	NS	NS	NS	NS	NS
Skeletal measurements															
PP/MP	18.88	5.53	23.34	3.82	27.27	4.74	34.42	4.41	<.001	<.001	<.001	<.001	<.001	<.001	<.001
PP/H	1.03	3.65	0.528	3.56	–2.21	3.99	–1.36	4.06	.001	NS	.001	.016	.006	NS	NS
MP/H	18.50	5.03	22.62	3.48	26.61	4.42	34.94	5.59	<.001	<.001	<.001	<.001	<.001	<.001	<.001
MP/SN	23.96	3.99	29.97	1.48	34.64	1.34	41.02	3.30	<.001	<.001	<.001	<.001	<.001	<.001	<.001
ANB	3.33	2.92	3.49	2.94	3.18	3.28	3.49	3.62	NS	NS	NS	NS	NS	NS	NS
Soft tissue chin measurements															
Pog-Pog’	11.78	3.37	11.48	2.41	11.36	2.55	10.69	2.09	NS	NS	NS	NS	NS	NS	NS
Gn-Gn’	9.58	2.19	9.28	2.43	9.00	2.97	7.47	2.42	<.001	NS	NS	<.001	NS	.002	.039
Me-Me’	7.57	1.72	7.22	1.96	7.15	1.85	6.30	1.89	.011	NS	NS	.008	NS	NS	NS

[a] MP/SN indicates mandibular plane to anterior cranial base; ANOVA, analysis of variance; SD, standard deviation; NS, not significant; PP/MP, palatal plane to mandibular plane; PP/H, palatal plane to horizontal; MP/H, mandibular plane to horizontal; Pog-Pog’, length between bony pogonion and its horizontal projection over the vertical passing through soft tissue pogonion; Gn-Gn’, distance between bony gnathion and soft tissue gnathion; Me-Me’, distance between bony menton and its vertical projection on the horizontal passing through soft tissue menton.

and $r = -0.177$ between STC thickness and MP/SN at the level of Me, Gn, and Pog, respectively. When the middle range groups ML and MH were excluded and the Pearson product moment computed only on the extreme divergence groups L and H, the correlation was higher but of moderate range ($r = -0.443$; $P < .001$).

Low to moderate correlations were also noted within each of the male ($r = -0.485$; $P < .05$) and female ($r = -0.387$; $P < .05$) groups.

DISCUSSION

The main contribution of this study was the association between mandibular vertical divergence and STC thickness. Patients with greater MP/SN angle has thinner STC, excluding Pog (Figure 2). This finding suggests that as the vertical expansion of the skeletal tissues increases, it impinges on the thickness of a soft tissue that no longer displaces in a corresponding ratio of 1:1. This ratio has been reported in clinically normal development and after orthognathic surgery of the mandible and chin.[9,10]

More specifically, the finding that ST thickness was statistically significantly different at Gn and Me but not at Pog suggests the presence of a differential extension between hard and soft tissues during growth. The STC thickness apparently adapts to severe hyperdivergence, presumably through increased

Table 3. Mean Measurements of Soft Tissue at the Chin in Groups Stratified on MP/SN and Gender [a]

	Group								
	Low, MP/SN ≤ 27°		Medium-Low, 27° < MP/SN ≤ 32°		Medium-High, 32° < MP/SN < 37°		High, MP/SN ≤ 37°		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	ANOVA (*P*)[b]
Men									
Pog-Pog’	13.50	4.41	12.30	2.41	12.76	2.47	11.01	2.35	NS
Gn-Gn’	10.59	2.12	10.21	2.28	10.58	2.91	8.12	2.44	.019
Me-Me’	8.55	1.70	7.81	1.92	8.27	1.65	6.76	2.03	NS
Women									
Pog-Pog’	10.58	1.55	10.80	2.23	10.40	2.18	10.52	1.96	NS
Gn-Gn’	8.85	1.98	8.52	2.32	7.90	2.55	7.15	2.39	.037
Me-Me’	6.86	1.38	6.73	1.88	6.39	1.60	6.07	1.81	NS

[a] MP/SN indicates mandibular plane to anterior cranial base; ANOVA, analysis of variance; SD, standard deviation; NS, not significant; Pog-Pog’, length between bony pogonion and its horizontal projection over the vertical passing through soft tissue pogonion; Gn-Gn’, distance between bony gnathion and soft tissue gnathion; Me-Me’, distance between bony menton and its vertical projection on the horizontal passing through soft tissue menton.

[b] Statistically significant differences only for Gn-Gn’ across groups: in men between low and high ($P = .022$) and medium-low and high ($P = .039$); in women between low and high ($P = 0.036$). All soft tissue at the chin measurements within each divergence group between men and women were statistically significantly different ($P = .001$–$.03$) except for group high.

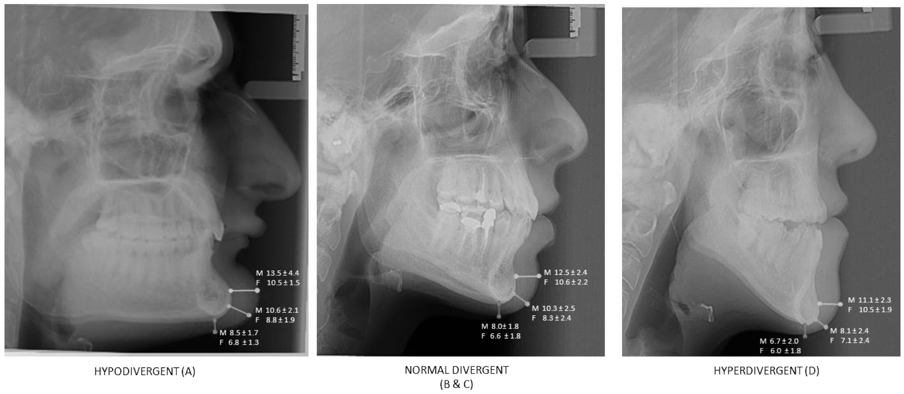

Figure 2. Mean measurements of soft tissue at the chin in groups low, medium (medium-low + medium-high), and high for men (M) and women (F).

stretching of the STC in children with progressive increase in facial divergence. Similar observations have been reported in studies of the effect of nasal obstruction on facial development, the long face syndrome being the most severe expression of such insult.[15,16]

The reason that might account for the lack of significance at Me rather than the statistical significance observed at Gn between group H and each of the medium groups ML and MH is that STC is thinner at Me, probably rendering it less stretchable than at Gn. The finding that group H was statistically significantly different from only group L at Me emphasizes the fact that extreme hyperdivergence is distinct from the other groups both in soft tissue thickness and in response to vertical growth because STC at Me in group H is actually the thinnest of all distances in all groups (6.30 mm; Table 2). The findings are further interpreted in the context of gender differences, growth, clinical implications, and research issues.

Gender Differences

Except for gender differences in group H, our findings are concurrent with those of other studies[17,18] that found thicker soft tissue in all aspects of the face in men compared with women. The exception in group H might be related to the similar effect of the STC reduction in subjects with the most hyperdivergence and increased lower face height; this hypothesis is discussed later in the context of differential growth between hard and soft tissues.

Growth Issues

Given that growth pattern, including the inclination of mandibular plane to anterior cranial base, tend to remain the same throughout development,[19] a similar pattern might exist with the STC. If developmental adaptation of the STC occurs, it appears to be differential along the chin contour, materializing mostly at the levels of Gn and Me. The STC at Pog was not statistically significantly different, similar to findings by Feres et al.,[12] who assessed the STC in different divergent patterns but only at the level of Pog. Gauging the longitudinal development of growing children with long face pattern, other authors reported increased STC growth at Pog in childhood and indicated that this camouflaged the vertical dysplasia.[20] However, this growth ceased earlier than in children with a short face pattern, which eventually caught up to the long face pattern. This finding supports our finding of similarity of STC at Pog across groups. Data are not available for longitudinal growth at Gn and Me.

The integumental comparisons of subjects from the Bolton growth study failed to depict morphologic differences between Class I and Class III malocclusions, supporting the tenet that the soft tissue envelope can mask (or accentuate) a sagittal skeletal discrepancy.[21] In our study, the latter, evaluated by the ANB angle, was not statistically significantly different among the divergence groups (Table 2); thus, it did not constitute an indicator for the vertical divergence classification.

Clinical Implications

The findings suggest that current projections of displacement of hard and soft tissue pogonion in a 1:1 ratio during growth and with orthognathic surgery of the mandible, at least in the sagittal plane, are supported.

Other implications that warrant focused research include

1) The possibility of a different response in the vertical plane, particularly at Gn and Me, whereby the vertical expansion of the skeletal tissues impinges on the thickness of a soft tissue that no longer displaces in a ratio of 1:1; accordingly,

changes sought at Gn and Me during surgery may not be relevant unless related to affecting changes in an increased lower face height.

2) The suspicion that even in the sagittal plane, a similar disproportion might develop at pogonion.
3) The possibility that more advancement genioplasty to achieve better chin projection may be needed in patients with severe hyperdivergence because the mandible has grown more vertically at the expense of its anterior projection; this premise would support the high rate of genioplasty we observed in patients with hyperdivergent long faces (nearly 75% in our academic center). By extension, earlier treatment in growing children might be recommended to favor the forward projection of the chin by removing obstacles to more horizontal growth (eg, sustained mouth breathing) and controlling the extrusion of posterior teeth.

These assumptions warrant the evaluation of simulation programs in which the algorithms for the displacement of Pog, Gn, and Me are established according to a ratio of 1:1 between soft and hard tissues. Particularly in hyperdivergent patterns, this ratio may not be the same as the hard tissue vertical expansion may have impinged on soft tissue thickness.

Research Issues

We stratified divergence in four groups to represent gradual severity toward the extreme forms of hypo- and hyperdivergence. The measures within one standard deviation on either side of the mean were considered within the wider normal range, guaranteeing the severity of the outer groups and enhancing the validity of conclusions. Accordingly, STC thicknesses in normodivergent subjects (groups ML and MH) should approach normative values, and in fact, they are compatible with norms reported in adult patients: when groups ML and MH are merged, the mean STC measurements (Figure 2) are concurrent with the initial norms set by Holdaway[22] (Pog-Pog' = 10–12 mm), and with the findings of Scheideman et al.,[23] who studied soft tissue thickness in a sample of adults with normal ANB angle.

Although the findings address the aim of our study to evaluate STC thickness as one contributing factor to chin extension, further investigation is required to assess the presence and contribution of other variables in defining the overall chin and facial esthetics. Additional contributors could be the shape and inclination of the bony chin, which Bjork[24] described as being receding and inclined backward in mandibles with posterior rotation compared with a more prominent symphysis in mandibles with anterior rotation. Other factors might reside in structures adjacent to the chin, such as the nose, which was reported to develop continuously even throughout adulthood,[25] whereby the common evaluation of the chin in reference to nose prominence by orthodontists is justified. Also, ethnic variations may be the source of differences in soft tissue thicknesses among people exhibiting normal occlusions.[26] Our sample comprised white subjects within a limited geographic area, minimizing the effect of ethnic differences on the results. A three-dimensional evaluation via computed tomographic images would probably provide more accurate assessment of facial soft tissues.

CONCLUSIONS

- Soft tissue thickness measurements were smaller in adult patients with vertical hyperdivergent pattern compared with adult patients with clinically normal and hypodivergent patterns.
- Subjects with hyperdivergent mandible exhibited a statistically significantly thinner STC at Gn and Me in comparison with subjects having a hypodivergent pattern.
- All STC measurements were greater in men than in women.
- The findings suggest that STC thickness in hyperdivergent pattern should be considered differently at its most anterior point (Pog) relative to its inferior landmarks (Gn and Me). This differential should be explored in further research, particularly given its potential implications for genioplasty in patients with extreme hyperdivergence who might require greater chin advancement to compensate for an increased vertical height and not only initially deficient chin projection.

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