Original Article

The Correlation of Smile Line with the Vertical Cephalometric Parameters of Anterior Facial Height

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Abstract:

Statement of the problem: In the evolution of orthodontics, the changes in soft tissue, especially smile line attracts considerable attention.

Purpose: The present study was carried out to evaluate the correlation of the smile line with the vertical parameters of anterior part of face.

Materials and Methods: Forty-six Iranian adults, aged between 18-25 years were selected. Five quantitative and three qualitative variables of smile analysis were recorded for each subject. Cephalometric analysis was carried out using angular and linear parameters. The correlations between smile line variables and cephalometric parameters were calculated using Spearman and Pearson's correlation analyses.

Results: The result of this study showed that the cephalometric parameters of N-Me, Pn-Line, N-B, N-Pg had significant correlations with quantitative variable of tooth-lower lip position. The P-values were P=0.003, P=0.027, P=0.006, P=0.002 respectively. N-Me, N-B, N-Pg represented significant correlations with interlabial gap on smile (P= 0.006, P=0.036, P=0.002 respectively). There was a significant correlation between N-Pg and quantitative factor of tooth-upper lip position (P=0.034). Upper incisor to palatal plane showed a significant correlation with qualitative variable of tooth-upper lip position (P=0.019), interlabial gap on smile (P=0.004), and tooth-upper lip position (P=0.006). Upper incisor to FH represented a reverse relation with incisal edge to lower lip (P=0.028).This parameter also showed significant correlations with quantitative factors of tooth-lower lip position (P=0.040) and crown height (P=0.002).

Conclusions: According to the results of this study, it can be concluded that, linear skeletal and dental vertical factors affect the vertical features of smile. Angular vertical parameters, except gonial angle, influence the vertical position of smile.

Key Words: Smile analysis; Vertical parameters; Soft tissue analysis

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INTRODUCTION

When a person senses happiness, pleasure, humor or greetings, a smile develops [1]. An attractive or pleasing smile clearly enhances the acceptance of an individual in the society by improving the initial impression in interpersonal relationships. The smile is one of the most important facial expressions and is essential in expressing friendliness, agreement, and appreciation [2].

The subject of the smile and facial animation as they relate to communication and expression of emotion is, and should be, of great interest to orthodontists [3].

Few objective criteria exist for assessing attributes of the smile, establishing lip-teeth relationships as objectives of treatment, or measuring the soft tissue outcomes of treatment. It would be nice to have some sort of a tool to assess beauty quantitatively but, currently, one does not exist and it probably never will. As a result, an eye for beauty is an important attribute for an orthodontist [3].

There are two basic types of smiles: the social smile and the enjoyment smile [4]. It is important to differentiate between the social smile and the enjoyment smile. The social smile is a voluntary smile a person uses in social settings or when posing for a photograph.

The enjoyment smile is an involuntary smile and represents the emotion you are experiencing at that moment. The enjoyment smile therefore has many descriptors, such as laughing, wry, knowing, or insipid [5].

In treating the smile, the social smile generally represents a repeatable smile. However, a social smile can mature and might not be consistent over time in some patients [5]. A characteristic of the esthetic smile that has not been as well recognized is the smile arc (line).

The smile arc from the frontal view is the relationship of the curvature of the incisal edges of the maxillary incisors and canines to the curvature of the lower lip in the posed social smile [6]. In an ideal smile arc, the curvature of the maxillary incisal edge is parallel to the curvature of the lower lip upon smile; the term consonant describes this parallel relationship [6]. In a non-consonant or flat smile, the maxillary incisal curvature is flatter than the curvature of the lower lip on smile [6].

The subject's inherent growth pattern may be an effective factor in characteristics of smile.

The studies of smile arc flattening revealed that, while treated patients did have a higher rate of smile arc flattening, 5% of the untreated population also experienced smile arc flattening. More vertical growth in the posterior maxilla than in the anterior maxilla could result in a changed relationship between the occlusal plane and the curvature of the lower lip upon smile. Growth in the brachyfacial pattern (low mandibular plane angle and a tendency for parallelism of the sella-nasion line, palatal plane and occlusal plane) may lead to a flat smile arc. Patients with this skeletal pattern might, theoretically have a tendency for the anterior maxilla to lack the clockwise tilt needed for an ideal smile arc; in some cases, it might even exhibit a counterclockwise tilt that results in a flat smile arc. Whether this is fact, however, is yet to be proven [3].

In 1992, a comparative study carried out to examine the nature of the gingival smile line (GSL), a specific dentolabial configuration characterized by the exposure of maxillary anterior gingiva during a full smile. Five soft tissue, three dental and three skeletal variables were selected, measured and reported for a GSL sample (n=27) and a reference sample (n=88). The results indicated that the capacity to project a gingival smile was related to anterior vertical maxillary excess and the muscular ability to raise the upper lip was significantly higher than average when smiling. Other variables significantly associated with GSL included greater overjet, greater interlabial gap at rest and greater overbite. Factors that did not appear to be associated with the GSL phenomenon were upper-lip length, clinical crown height of incisor, mandibular plane angle and palatal plane angle [1].

The other study performed to evaluate quantitatively upper lip-tooth-jaw relationship in the vertical dimension. This study showed significant sexual dimorphism in the vertical lip-tooth-jaw relationship. There was a significant sex difference in upper lip length. However, a significant difference was seen in the skeletal maxillary height measurement

between male and female. Furthermore, a significant difference was found between the clinical crown height of the maxillary central incisors in the male and female subjects of comparable ages [7].

Since there are few studies in the relationship of the smile line to the dental changes and skeletal pattern, the present study of the smile line was performed to evaluate the relationship between the smile line and vertical cephalometric parameters of anterior part of the face. Skeletal and dental variables and characteristics of smile line were measured and evaluated.

MATERIALS AND METHODS

This investigation was planned as a cross-sectional study. The study subjects were collected from private orthodontic offices and Department of Orthodontics, Tehran University of Medical Sciences. Forty six patients (23 girls, 23 boys), aged between 18-25 years old (mean 22 years) comprised the study sample. The following selection criteria were used: no history of previous orthodontic treatment or maxillofacial surgery, overjet between 0 to 4 mm, overbite between -2 to 6 mm, normal upper lip length, no craniofacial anomalies or severe malocclusion, no canting in occlusal plane.

Data were compiled for each subject. Since in treating the smile, the social smile generally represents a repeatable smile, for the purpose of smile analysis, the subjects were asked to pose a smile and then smile line variables were measured and recorded.

Five quantitative variables of smile line were measured directly on the face using vernier calipers that included:

1- Tooth-upper lip position: the distance in millimeters between incisal edge of the maxillary incisor and upper lip.

2- Tooth-lower lip position: the distance in millimeters between incisal edge of the maxillary incisor and lower lip.

3- Interlabial gap on smile: the distance in millimeters between upper and lower lip on smile.

4- Gingival display: the amount of gingival display on smile in millimeters.

5- Crown height: the vertical height of the maxillary central incisors in millimeters.

Three qualitative variables of smile line were recorded by careful observation including:

1- Tooth-upper lip position: the position of the upper lip relative to maxillary incisors on smile. It was divided into three categories: low smile, average smile, high smile.

2- Incisal edge to lower lip: the parallelism of the upper incisal curve with the inner curvature of the lower lip. Three groups were identified in this category: convex curve, straight, reverse.

3- Tooth-lower lip position: the position of the incisal curve relative to the position in which touching the lower lip. Three groups were identified: not touching, touching, and slightly covered.

For each subject, the lateral cephalometric radiograph was traced. All Cephalograms were taken with the teeth in occlusion and the lips in a relaxed position.

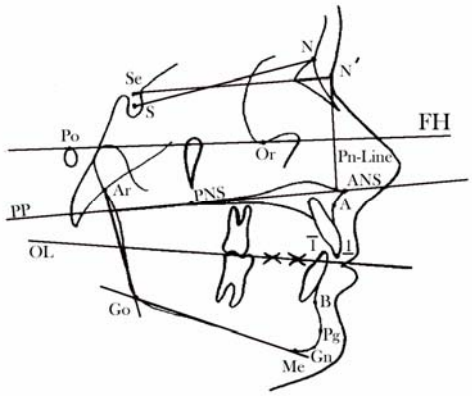

Fig. 1: Reference points : sella (S), nasion (N), point A (A), point B(B), pogonion (Pg), gnathion (Gn), menton (Me), gonion (Go), articular (Ar), porion (Po), orbital (Or), anterior nasal spine (ANS), posterior nasal spine (PNS), soft tissue nasion (N`), upper incisor (1), lower incisor (1), sella entrance (Se). Reference lines : sella-nasion (SN), Frankfort plane (FH), palatal plane (PP), functional occlusal line (OL), mandibular plane (GoMe), sella entrance–soft tissue nasion (Se-N`), line perpendicular to Se N` passing through PP (Pn-line).

A cephalometric analysis was carried out using the reference points and lines (Fig. 1) to assess smile line using angles and distances (Fig. 2).

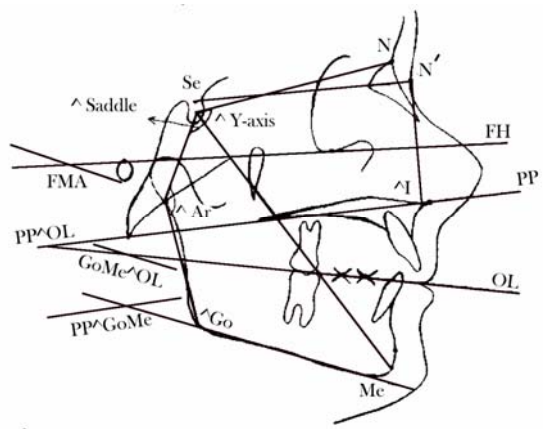

Fig. 2: Vertical analysis; angular measurment (º): FMA, PP^ GoMe, PP^OL, GoMe^OL, ^Y-axis, ^Inclination, ^Gonial, Articular, Saddle; linear measurement (mm): Pn-line, S-Go, N-Me, N-A, N-B, N-Pg, and Jarabak index ($\frac{S-Go}{N-Me}$), $\underline{1}$-PP, $\underline{1}$-FH, $\bar{1}$-Go Me.

Ten randomly selected patients were re-examined after their initial examination for quantitative variables of smile line and the kappa test was used to test intra-examiner reliability (kappa 0.80). Kappa values above 0.60 indicate substantial agreement.

Spearman's correlation coefficient was used to calculate the correlations between ordinal variables and quantitative variables and Pearson's correlation coefficient was used to calculate associations between quantitative variables. A significance level of $P<0.05$ was used.

RESULTS

The correlations between skeletal vertical variables and smile line variables are represented in Tables I and II.

Anterior facial height (N-Me) showed a positive relation with quantitative variables of tooth-lower lip position and interlabial gap on smile.

Pn-line showed a significant correlation with a quantitative variable of tooth-lower lip position.

N-B showed significant correlations with quantitative variables of interlabial gap on smile and tooth-lower lip position.

There were significant correlations between N-Pg and quantitative variables of interlabial gap on smile, tooth-lower lip position, and tooth-upper lip position.

FMA showed a significant association with interlabial gap on smile.

There were significant correlations between ^Y-axis and quantitative variables of tooth-lower lip position, interlabial gap on smile, and tooth-upper lip position.

PPˆGoMe represented significant correlations with quantitative variables of tooth-upper lip position and interlabial gap on smile.

There were significant associations between PPˆOL and quantitative factors of tooth-lower lip position and interlabial gap on smile.

The correlations between dental vertical factors and smile line variables are shown in tables III, IV.

Table I: The Correlations between skeletal vertical variables and qualitative factors of smile line*.

		N-Me	S-Go	Pn-line	Jarabak index	N-A	N-B	N-Pg	Saddle angle
Tooth – upper lip position	R	0.052	-0.125	-0.018	-0.152	0.045	0.031	0.103	0.084
	P	0.734	3.408	3.907	0.315	0.767	0.839	0.495	0.579
Incisal edge to lower lip	R	-0.175	-0.012	-0.206	0.104	-0.185	-0.156	-0.143	-0.067
	P	0.245	0.936	0.081	0.492	0.219	0.299	0.344	0.658
Tooth – lower lip position	R	0.272	0.092	0.046	-0.116	-0.026	0.182	0.268	-0.047
	P	0.067	0.542	0.763	0.441	0.866	0.227	0.072	0.757

Table I (continue): Correlations between skeletal vertical variables and qualitative factors of smile line*[§].

		Articular angle	Gonial angle	FMA	Y – axis angle	Inclination angle	PP^GoMe	PP^Ol	GoMe^OL
Tooth – upper lip position	R	0.076	0.018	0.171	0.266	-0.003	0.223	0.128	0.237
	P	0.616	0.908	0.256	0.075	0.986	0.137	0.396	0.113
Incisal edge to lower lip	R	-0.069	-0.030	0.071	0.029	0.135	-0.048	-0.126	0.101
	P	0.647	0.843	0.641	0.848	0.372	0.751	0.405	0.506
Tooth – lower lip position	R	0.000	0.127	0.119	0.080	0.035	0.109	0.025	0.182
	P	1.000	0.402	0.431	0.597	0.816	0.471	0.867	0.226

* Spearman's rho, R= Correlation Coefficient, P=2-tailed significance.
§ No significant correlation was found.

Table II: The Correlations between skeletal vertical variables and quantitative variables of smile line*.

		N-Me	S-Go	Pn-line	Jarabak index	N-A	N-B	N-Pg	Saddle angle
Tooth – upper lip position	R	0.274	0.076	0.186	-0.264	0.202	0.180	0.313	0.134
	P	0.066	0.617	0.217	0.076	0.178	0.231	0.034	0.375
Tooth – lower lip position	R	0.438	0.178	0.329	-0.149	0.274	0.400	0.457	0.033
	P	0.003	0.242	0.027	0.330	0.069	0.006	0.002	0.830
Lnterlabial gop on smile	R	0.402	0.008	0.186	-0.277	0.271	0.310	0.441	0.137
	P	0.006	0.957	0.217	0.063	0.069	0.036	0.002	0.362
Gingival display	R	0.122	0.052	0.106	-0.127	0.052	0.046	0.149	0.037
	P	0.420	0.732	0.484	0.400	0.732	0.761	0.323	0.805
Crown height	R	0.170	0.167	0.217	0.055	0.196	0.184	0.139	-0.250
	P	0.260	0.268	0.147	0.715	0.193	0.222	0.357	0.094

Table II (Continue): The Correlations between skeletal vertical variables and quantitative variables of smile line*.

		Articular angle	Gonial angle	FMA	Y – axis angle	Inclination angle	PP^GoMe	PP^Ol	GoMe^OL
Tooth – upper lip position	R	0.181	-0.048	0.270	0.406	-0.088	0.293	0.260	0.208
	P	0.229	0.754	0.070	0.005	0.561	0.048	0.080	0.165
Tooth – lower lip position	R	0.217	0.002	0.249	0.346	-0.053	0.230	0.331	0.059
	P	0.152	0.988	0.099	0.020	0.732	0.129	0.027	0.701
Lnterlabial gop on smile	R	0.196	-0.003	0.319	0.464	-0.112	0.326	0.318	0.210
	P	0.193	0.984	0.030	0.001	0.457	0.027	0.031	0.162
Gingival display	R	0.153	-0.045	0.160	0.238	-0.072	0.153	0.246	0.020
	P	0.309	0.766	0.287	0.112	0.636	0.310	0.099	0.895
Crown height	R	0.236	-0.100	0.051	-0.086	-0.081	-0.070	-0.027	-0.078
	P	0.114	0.507	0.736	0.571	0.591	0.642	0.856	0.605

* Spearman's rho, R= Correlation Coefficient, P=2-tailed significance.
Under lined figures represent significant correlation.

1-PP showed a significant correlation with a qualitative variable of tooth-upper lip position. Furthermore, there were significant relations between 1-PP and quantitative factors of interlabial gap on smile and tooth-upper lip position.

Table III: The correlations between dental vertical variables and quantitative variables of smile line*.

		1-PP	1-FH	$\bar{1}$-GoMe
Tooth-upper lip position	R	0.401*	0.062	0.201
	P	0.006*	0.682	0.180
Tooth- lower lip position	R	0.270	0.307*	0.487*
	P	0.073	0.040*	0.001*
Interlabial gap on smile	R	0.421*	0.178	0.360*
	P	0.004*	0.237	0.014*
Gigival display	R	0.274	0.155	0.127
	P	0.065	0.303	0.399
Crown height	R	0.132	0.451*	0.131
	P	0.382	0.002*	0.385

* Spearman's rho, R= Correlation Coefficient, P=2-tailed significance, and *Represent significant correlation.

1-FH represented a reverse relation with incisal edge to lower lip. Also 1-FH showed significant correlations with quantitative variables of tooth-lower lip position and crown height. There was a significant association between $\bar{1}$-GoMe and a qualitative factor of tooth-lower lip position. Also $\bar{1}$-GoMe showed significant correlations with quantitative variables of tooth-lower lip position and interlabial gap on smile.

DISCUSSION

In the evolution of orthodontics, the changes in soft tissue especially smile line attracts a considerable attention. Skeletal and dental changes affect the smile line. In this study, the relationship between smile features and skeletal-dental changes were evaluated.

Vertical skeletal variables such as N-Me, Pn-line, N-B, N-Pg showed positive relations with quantitative variables of tooth-lower lip position. In other words, higher N-Me, Pn-line, N-B, N-Pg were associated with a greater distance between incisal edge of the maxillary incisor and lower lip.

Vertical skeletal factors such as N-B, N-Me, N-Pg represented significant correlations with a quantitative variable of interlabial gap on smile. It means that higher N-B, N-Me, N-Pg shows a greater distance between upper and lower lip on smile. It could probably because of greater tension of soft and muscular tissues.

N-Pg showed a significant relation with a quantitative factor of tooth-upper lip position, which means upper tooth exposure and gingival display on smile were greater in higher anterior facial height.

A general look at these finding reveals that these vertical parameters affects the vertical features of smile.

Vertical skeletal angles such as FMA, ^Y-axis, PPˆGoMe, PPˆOL represented significant associations with interlabial gap on smile. It means that increasing these angles cause a vertical development in individuals' faces which cause increasing in interlabial gap on smile.

Table IV: The correlations between dental vertical variables and quantitative variables of smile line*.

		1-PP	1-FH	$\bar{1}$-GoMe
Tooth-upper lip position	R	0.344*	-0.051	0.080
	P	0.019*	0.737	0.597
Incisal edge to lower lip	R	-0.125	-0.324*	-0.103
	P	0.408	0.028*	0.497
Tooth- lower lip position	R	0.149	0.158	0.435*
	P	0.323	0.294	0.002*

* Spearman's rho, R= Correlation Coefficient, P=2-tailed significance, and *Represent significant correlation.

There were significant correlations between ^Y-axis, PPˆGoMe and a quantitative factor of tooth-upper lip position. In other words,

increasing these angles shows greater upper tooth exposure and gingival display on smile.
^Y-axis, PPˆOL represented significant correlations with a quantitative variable of tooth-lower lip position. Increasing these angles shows a vertical development in the subjects' faces, which cause increasing the distance between incisal edge of the maxillary incisor and lower lip. A general look at results reveals that vertical angles evaluated in this study, affect the vertical features of smile.
Although it seemed that inclination angle affect the smile, no correlation between inclination angle and smile line variables was found. This angle shows clockwise or counter clockwise tilt in maxilla. Sarver stated that patients with brachyfacial pattern might, theoretically, have a tendency for the anterior maxilla to lack the clockwise tilt needed for an ideal smile arc; in some cases, it might even exhibit a counter clockwise tilt that results in a flat smile arc [3]. Further investigations will be needed to evaluate this theory. However, the results of this study did not prove the relation between tilt in maxilla and smile arc.
The results of this study showed a significant association between 1-PP and qualitative variable of tooth–upper lip position. It means that with increasing the distance between maxillary incisor and palatal plane, patients' smile tends to change from low smile to high smile, which can be expected because greater distance will cause greater upper tooth exposure and gingival display. This study also showed a significant correlation between 1–PP and quantitative factor of tooth–upper lip position. 1-PP (palatal plane to upper incisor edge) indicates anterior maxillary height, and higher 1-PP shows greater anterior maxillary height. There are other studies which proposed the same relationship in their study [1, 7]. In both studies anterior vertical maxillary excess were introduced as an effective factor on gingival smile line (GSL). Findings of this study showed a significant association between 1-PP and inter-labial gap on smile.
The results showed a reverse relation between 1-FH and incisal edge to lower lip. In other words, by increasing the distance between upper incisor edge to FH, patients' smile tend to from a convex curve. In fact, maxillary incisor is in lower position comparing to its adjacent teeth and forms a curve. 1-FH showed significant associations with quantitative factors of tooth-lower lip position and crown height. It may be related to development of anterior facial height or extrusion of maxillary incisors.
There was a significant association between $\bar{1}$-GoMe and quantitative factor of tooth-lower lip position, which means the higher $\bar{1}$-GoMe result in greater distance between incisal edge of the maxillary incisor and lower lip. Also higher $\bar{1}$-GoMe showed a greater distance between upper and lower lip on smile. The findings showed a significant relation between $\bar{1}$-GoMe and qualitative factor of tooth-lower lip position. It means that increasing the distance between lower incisor edge and mandibular plane result in the lower lip to move far from maxillary incisors while smiling.

COCLUSION

According to the result of this study can be concluded that linear skeletal and dental vertical factors affect the vertical features of smile, which means vertical development in the individuals' faces cause the distance between incisal edge of the maxillary incisor and lower lip , interlabial gap on smile , upper tooth exposure and gingival display on smile to be increased. Angular vertical parameters of the face, except Gonial angle, influence the vertical features of smile the same as linear vertical factors of the face.

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بررسی ارتباط خط لبخند با اندازه‌های سفالومتری بُعد عمودی در ناحیه قدامی صورت

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چکیده

بیان مسأله: در ارتودنسی نوین، تغییرات بافت نرم بخصوص خط لبخند بسیار مورد توجه است.

هدف: مطالعه حاضر با هدف تعیین رابطه خط لبخند در اندازه‌های سفالومتری بعد عمودی ناحیه قدامی صورت انجام شد.

روش تحقیق: در این مطالعه، ۴۶ فرد ایرانی ۱۸ تا ۲۵ ساله انتخاب شدند و ۵ متغیر کمی و ۳ متغیر کیفی مربوط به آنالیز لبخند در آنها ثبت گردید. خطوط و زوایای مورد نظر در سفالومتری نیز اندازه‌گیری شدند و ارتباط بین این دو سری داده با استفاده از آزمونهای همبستگی Spearman و Pearson مورد بررسی قرار گرفت.

یافته‌ها: بین متغیر رابطه لب پایین با دندانها، با متغیرهای سفالومتریک N-Me (P=۰/۰۰۳)، Pn-Line (P=۰/۰۲۷)، N-B (P= ۰/۰۰۶) و N-Pg (P= ۰/۰۰۲) همبستگی معنی‌داری به دست آمد. فاصله بین دو لب در هنگام لبخند با N-Me (P=۰/۰۰۶)، N-B (P=۰/۰۳۶) و N-Pg (P=۰/۰۰۲) همبستگی معنی‌داری را نشان داد. همبستگی معنی‌دار آماری بین N-Pg و متغیر کیفی رابطه لب بالا با دندانها وجود داشت (P=۰/۰۳۴). همبستگی معنی‌داری بین زاویه دندان سانترال بالا با پلن پالاتال با متغیر کمی رابطه لب بالا با دندانها (P=۰/۰۱۹)، فاصله بین دو لب در هنگام لبخند (P=۰/۰۰۴) و متغیر کیفی رابطه لب بالا با دندانها (P=۰/۰۰۶) مشاهده شد. زاویه دندان سانترال بالا با پلن فرانکفورت افقی رابطه معکوسی با فاصله بین لبه دندانهای قدامی بالا با لب پایین (P=۰/۰۲۸) داشت. این شاخص همچنین همبستگی معنی‌داری با شاخصهای کمّی رابطه لب پایین و دندانها و طول تاج کلینیکی نشان داد.

نتیجه‌گیری: با توجه به نتایج این مطالعه می‌توان گفت که شاخصهای عمودی خطی دندانی و استخوانی بر شاخص‌های عمودی لبخند تأثیر می‌گذارند؛ همچنین زوایای عمودی نیز به جز زاویه‌های گونیال بر مؤلفه‌های عمودی لبخند مؤثر هستند.

واژه‌های کلیدی: آنالیز لبخند؛ مؤلفه‌های عمودی؛ آنالیز بافت نرم

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