Original Article

Soft tissue response after Class III bimaxillary surgery
Impact of surgical change in face height and long-term skeletal relapse

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ABSTRACT
Objective: To analyze the impact of surgical change in anterior face height and skeletal relapse on the long-term soft tissue profile.
Materials and Methods: Cephalometric radiographs of 81 patients taken before surgery and at five time points during a 3-year follow-up period were analyzed. All patients had Le Fort I and bilateral sagittal split osteotomies. The patients were divided into three subgroups according to the change in anterior face height during surgery. Calculations of soft to hard tissue ratios were based on the long-term soft tissue response relative to the surgical repositioning.
Results: The horizontal surgical repositioning varied considerably, depending on whether anterior face height was increased or decreased. For upper lip prominence, the pattern of long-term change was the same irrespective of change in face height. In all groups, upper lip thickness decreased in both the short term and the long term, particularly in patients with surgical increase in face height. Lower lip thickness increased in the short term but decreased during the follow-up period. There were significant associations between horizontal soft tissue and corresponding hard tissue changes, except for soft tissue A-point and upper lip, when face height was increased. The ratios were higher for mandibular variables than for maxillary variables, particularly for B-point and pogonion when anterior face height had decreased.
Conclusion: A change in facial height influences the soft tissue response. The mandibular soft tissues closely follow skeletal relapse beyond 2 months postsurgery. The findings have clinical implications for the relative maxillary and mandibular repositioning when planning surgery. (*Angle Orthod.* 2013;83:533–539.)

KEY WORDS: Orthognathic surgery; Soft tissue response; Class III malocclusion

INTRODUCTION

An important goal of orthognathic surgery is to improve facial harmony, and clinicians require tools to predict postsurgical soft tissue changes that also facilitate communication with the patient. Software that predicts soft tissue responses is usually based on studies reporting ratios of soft to hard tissue changes. However, these ratios often do not take into account potential long-term skeletal relapse. Some authors have therefore suggested that ratios should be established that incorporate both soft and hard tissue relapse, and such ratios have been presented for mandibular setback surgery.[1,2] Other factors that have been suggested to influence postoperative stability of the soft tissues include the preoperative soft tissue thickness,[1,3,4] gender,[1,5] and the amount of surgical movement.[1,6] It has been proposed that most of the postsurgical change in the soft tissue profile takes place during the first year.[1,7–9] Some reports on short-term soft tissue changes after bimaxillary correction of Class III malocclusion are available,[6,10–16] but few have addressed the long-term changes in the soft tissues.[8,17]

Bimaxillary surgery has a greater potential to decrease or increase anterior face height compared to one-jaw osteotomies, and the soft tissues may be affected by relaxation or stretching. The relative amount of maxillary advancement and mandibular setback should also be planned according to the desired profile changes and should take into account the extent to which the soft tissues follow the hard

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tissue relapse in the long term. The purpose of the present study, therefore, was to analyze long-term changes in the soft tissue facial profile following Class III bimaxillary surgery with the objective to determine whether a decrease or increase in face height during surgery affects the profile changes, with emphasis on the anteroposterior (AP) direction. An additional objective was to analyze to what extent the soft tissues follow the skeletal long-term relapse.

MATERIAL AND METHODS

The sample comprised 84 consecutively operated patients who all underwent a combination of a standard one-piece Le Fort I osteotomy and bilateral sagittal split osteotomy with rigid fixation that involved two miniplates on each side in the maxilla and three 2.0-mm bicortical screws with washers on each side in the mandible. Details of the surgical procedure have been described previously.[18] A team of five senior surgeons was involved in the surgery. None of the patients had undergone additional surgery such as genioplasty. Patients with syndromes, cleft of the lip and/or palate, or dentofacial trauma were excluded from the study. Patient data were retrieved from the files at the Department of Orthodontics, University of Oslo. Surgery had been performed at the Oslo University Hospital, Ullevaal, between 1990 and 2003. The patients were monitored over a 3-year period. In the present study, the records obtained within 1 week prior to surgery (T1); within 1 week after surgery (T2); 2, 6, and 12 months after surgery (T3, T4, and T5); and 3 years after surgery (T6) were used. Cephalograms of 81 patients (55 male and 26 female patients) were available. When examining the effect of skeletal relapse on postsurgical soft tissue morphology, we focused on changes occurring between T3 and T6 because of postsurgical swelling at T2. The short-term soft tissue response was thus calculated as changes from T1 to T3. Soft tissue to hard tissue ratios were calculated from the long-term soft tissue response (T1 to T6) relative to surgical repositioning (T1 to T2). The age of the patients at the time of surgery varied from 15.7 to 49.2 years, with a mean of 24.4 years (standard deviation [SD] 7.3 years).

To analyze the effect of changes in anterior face height (AFH) recorded between T1 and T2, the patients were allocated to one of three subgroups: the No Change group, ie, a change in AFH of less than 2 mm ($n = 30$); the Decrease group, ie, patients showing a decrease in AFH of 2 mm or more ($n = 40$); or the Increase group, ie, subjects with an increase in AFH of 2 mm or more ($n = 11$). Six patients in the increase group received bone grafts when the maxilla was repositioned downward. Changes in the positions of anatomical landmarks were recorded using a coordinate system (Figure 1). In addition, two angular measurements (nasolabial angle and mentolabial angle) and two linear measurements (upper and lower lip thickness) were made. All cephalograms were hand-traced, and the tracings were scanned and digitized with Dentofacial Planner Plus software (Dentofacial Software, Toronto, Ontario, Canada). The cephalometric analysis and analysis of method error have been described previously.[16]

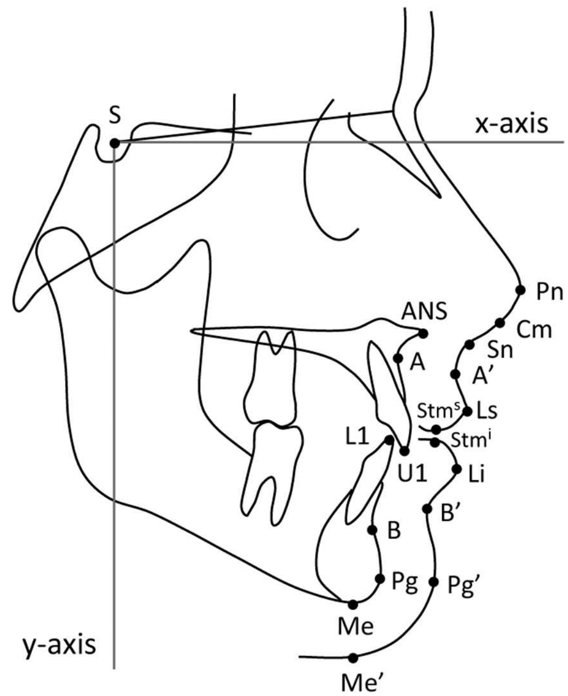

Figure 1. Skeletal, dental, and soft tissue landmarks applied in the cephalometric analysis. A indicates A-point; A′, soft tissue A-point; ANS, anterior nasal spine; B, B-point; B′, soft tissue B-point; Cm, midpoint of columella of the nose; L1, superiormost point of the lower incisors; Li, labrale inferior; Ls, labrale superior; Me, menton; Me′, soft tissue menton; Pg, pogonion; Pg′, soft tissue pogonion; Pn, pronasale; S, sella; Sn, subnasale; Stm^s and Stm^i, stomion superius and inferius, respectively; and U1, inferiormost point of the upper incisors.

Statistical analyses were performed with SPSS for Windows (SPSS, Chicago, Ill). Paired *t*-tests were used to analyze changes between time points within subgroups, and analysis of variance (ANOVA) was applied to examine differences between subgroups. Associations between soft and hard tissue changes were analyzed with Pearson's correlation coefficients. The study was approved by the Norwegian Social Science Data Services (Project no. 31004).

RESULTS

The hard and soft tissues followed the same patterns of change in female and male patients, except for soft tissue B-point; the data were therefore pooled.

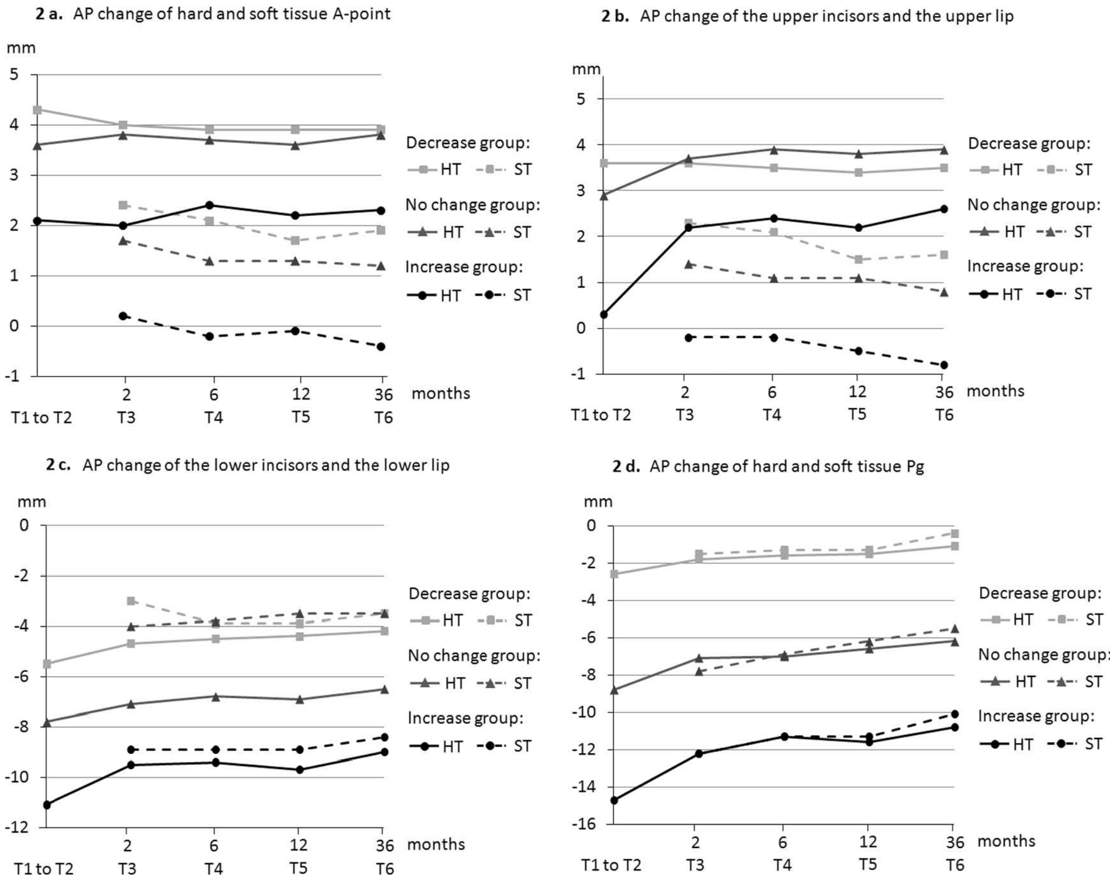

Figure 2. Mean anteroposterior changes at hard tissue (HT) and soft tissue (ST) landmarks as a function of time in each subgroup (No Change, Decrease, and Increase in AFH during bimaxillary surgery). The zero point on the *y*-axis represents the presurgical position. The value on the *y*-axis at the zero point on the *x*-axis represents the surgical change (T1 to T2). (a) Changes in A-point. (b) Changes in upper incisors and upper lip. (c) Changes in lower incisors and lower lip. (d) Changes in Pg.

The mean longitudinal hard tissue and corresponding soft tissue changes in the AP direction for A-point, upper and lower incisors, and Pg appear in Figure 2.

Surgical Repositioning and Skeletal Relapse

On average, AFH was reduced by 5.5 mm in the Decrease group and increased by 7.3 mm in the Increase group (Table 1). Reduction in face height was mainly a result of mandibular repositioning, whereas an increase in AFH was a result of both maxillary and mandibular changes. The mean maxillary and mandibular surgical AP change differed among the groups: maxillary advancement at A was greatest in the No Change and Decrease groups (3.6 and 4.3 mm, respectively, versus 2.3 mm in the Increase group). In contrast, mandibular setback was greatest in the Increase group (15.4 mm at Pg) and least in the Decrease group (2.6 mm). Maxillary advancement was stable over the long term, whereas mandibular relapse at Pg varied from 1.7 mm in the Decrease group to 4.6 mm in the Increase group. The amounts of vertical relapse at ANS and Me were only minor in the No Change and Decrease groups but were notable in the Increase group (47% and 58% of the surgical change, respectively). The differences between the three groups were statistically significant for all variables, except for short-term change at A and long-term change of U1.

Soft Tissue Changes

The mean nasiolabial angle increased significantly, particularly in the Increase group, and the changes were stable in all groups (Table 2). A reduction in the mentolabial angle was observed in all groups; less relapse was seen in the Increase group than in the two other groups. Upper lip thickness (Ls-U1) decreased after surgery and continued to decrease in all groups similarly. Upper lip (Ls) prominence had relapsed to the presurgery level in the Increase group, whereas it was about 2 mm more anterior in the Decrease group (Figure 2b). Lower lip thickness (Li-L1) increased in all groups after surgery, and the net long-term increase was greatest in the Decrease group (Table 2). At the 3-year follow-up, the lower lip was about 3.5 mm

Table 1. Mean (SD) Skeletal Changes (mm)[a] in the Groups During Surgery (T1 to T2) and Postsurgery (T2 to T6)

	No Change Group (n = 30)				Decrease Group (n = 40)				Increase Group (n = 11)				*P* Values	
	T1 to T2		T2 to T6		T1 to T2		T2 to T6		T1 to T2		T2 to T6		T1 to T2	T2 to T6
Horizontal changes														
A-point	3.6***	(2.3)	0.2	(1.0)	4.3***	(2.6)	−0.4**	(1.0)	2.3**	(1.6)	0.2	(1.0)	.056	.030
U1	3.0***	(3.1)	0.9*	(1.8)	3.6***	(3.9)	0.0	(1.6)	0.2	(2.1)	2.6**	(1.9)	.019	.000
L1	−7.8***	(3.7)	1.3**	(2.3)	−5.5***	(3.8)	1.4***	(1.4)	−11.1***	(3.0)	2.3***	(1.5)	.000	.263
B-point	−8.2***	(4.6)	1.6**	(2.5)	−4.1***	(4.5)	1.2***	(1.7)	−13.7***	(3.4)	3.8***	(1.6)	.000	.001
Pg	−8.5***	(5.6)	2.2***	(2.6)	−2.6**	(5.6)	1.7***	(2.2)	−15.4***	(3.9)	4.6***	(2.1)	.000	.002
Vertical changes														
ANS	1.6*	(3.2)	−0.7*	(1.6)	−1.0 *	(3.0)	−0.3	(1.2)	4.9***	(2.9)	−2.3*	(2.5)	.000	.001
U1	2.5***	(3.1)	−1.0*	(2.1)	−0.9	(3.0)	−0.4	(1.3)	5.5***	(2.7)	−3.6***	(2.3)	.000	.000
L1	0.4	(1.8)	−1.4**	(2.4)	−6.0***	(2.6)	0.0	(1.6)	7.5***	(3.4)	−4.1**	(3.4)	.000	.000
Me	0.1	(1.2)	−1.0**	(1.9)	−5.5***	(2.2)	0.5	(1.8)	7.3***	(4.1)	−4.2**	(3.3)	.000	.000

[a] Positive values indicate forward and downward movement; negative values indicate backward and upward movement.
Statistical significance of changes between time points within the groups (paired *t*-test): * $P \leq .05$; ** $P \leq .01$; *** $P \leq .001$.
Statistical significance of differences between the three groups was tested by ANOVA.

posterior compared to the presurgical position in the Decrease group, versus more than 8 mm in the Increase group (Figure 2c). The mean changes in the nasiolabial and mentolabial angles did not differ significantly between the groups in the long term. The soft tissue chin relapsed slightly more than the underlying hard tissue in the groups (range, 0.4–1.4 mm; Figure 2d).

Association Between Skeletal Relapse and Soft Tissue Change from 2 Months to 3 Years After Surgery

A′ and Ls tended to relapse in all groups, whereas the corresponding hard tissues remained stable in the long term (T3 to T6) (Figure 2a,b). Li and Pg′ closely followed the hard tissue relapse (Figure 2c,d). The ratios for soft to hard tissue change and corresponding correlation coefficients appear in Table 3. There were significant associations between AP soft and hard tissue changes, except for A′ and Ls, when face height was increased. Ratios for soft to hard tissue variables and correlation coefficients were generally higher for mandibular than for maxillary variables. The highest ratios and correlation coefficients, about 90% and 0.9, respectively, were observed for B and Pg in the Decrease group. For vertical variables, all correlations were significant when face height was decreased. No significant associations were found for the other groups, except that Li change correlated negatively with L1 repositioning when face height was increased (Table 3).

DISCUSSION

In previous long-term studies of isolated mandibular setback[1,2] that presented ratios for soft to hard tissue changes, soft tissue response was related to the hard tissue changes (1) during surgery and (2) at the end of the observation period. Because significant relapse occurred in several of the variables, it was considered most relevant to calculate ratios based on the net (T1 to T6) soft tissue change relative to the immediate (T1 to T2) surgical skeletal change. Ratios calculated from changes in soft to hard tissues over the same time interval are generally higher because they do not incorporate the effect of skeletal relapse.[1,2]

A number of corresponding soft and hard tissue changes were closely related, particularly AP changes in the mandible, whereas other landmarks changed quite independently. This may be a result of different characteristics such as the extent and volume of soft tissues, but it could also be attributed to functional aspects such as muscular tonicity in the midface region.[8] Proffit and Phillips[19] investigated changes in lip pressure after orthognathic surgery and found a decrease in resting pressure of the upper lip when the maxilla was advanced. Previous studies[20,21] have shown extension of the head after mandibular setback to compensate for a decrease in upper airway space. An experimental study by Hellsing and L'Estrange[22] observed an increase in upper lip pressure in conjunction with extension of the head. A slightly greater anterior movement of soft tissue vs hard tissue chin may be attributed to thickening of the soft tissue in the area. A long-term thickening of the soft tissue chin after Class III surgery was observed previously.[8] Although some changes often attributed to aging, such as lengthening of the upper lip, thickening of the chin, and thinning of the lips,[23–25] were observed in the present study, a more extensive follow-up period is required before a conclusion can be reached about the effect of aging.

Comparison Between Groups

Net AP changes in A′ and Ls positions were limited in all groups and are most likely related to the long-

Table 2. Mean (SD) Soft Tissue Angular (°) and Linear (mm) Changes in the Groups Short- (T1 to T3) and Long-Term (T3 to T6)

	No Change Group (n = 30)				Decrease Group (n = 40)				Increase Group (n = 11)				*P* Values	
	T1 to T3		T3 to T6		T1 to T3		T3 to T6		T1 to T3		T3 to T6		T1 to T3	T3 to T6
Nasolabial angle[a]	3.5*	(8.1)	0.2	(3.3)	−1.4	(10.0)	−0.2	(6.7)	12.2*	(17.7)	−1.0	(7.5)	.001	NS
Mentolabial angle[a]	−11.9***	(11.8)	2.9	(8.0)	−17.9***	(12.9)	5.9***	(7.8)	−8.3*	(11.4)	0.9	(10.0)	.036	NS
Upper lip thickness	−1.7**	(3.1)	−1.2***	(1.1)	−1.3**	(2.5)	−1.0***	(1.5)	−2.4*	(2.8)	−1.4*	(1.6)	NS	NS
Lower lip thickness	2.5***	(2.2)	−1.0*	(2.0)	3.3***	(2.5)	−1.3***	(1.3)	1.6*	(2.1)	−0.5	(2.1)	NS	NS
Upper lip length	−0.3	(3.1)	0.4	(1.2)	−0.3	(2.3)	0.8**	(1.4)	−1.5	(3.1)	0.5	(1.6)	NS	NS

[a] Nasolabial angle: the angle defined by the intersection of the line connecting Cm and Sn and the line connecting Sn and Ls; mentolabial angle: the angle defined by the intersection of the line connecting Li and B′ and the line connecting B′ and Pg′.

Statistical significance of changes between time points within the groups (paired *t*-test): * $P \leq .05$, ** $P \leq .01$, *** $P \leq .001$.

Statistical significance of differences between the three groups was tested by ANOVA.

term reduction in lip thickness (Ls-U1), which is in accordance with a previous long-term study of Class III bimaxillary surgery.[8] One study observed that the changes in the nasiolabial and mentolabial angles were not predictable after bimaxillary Class III surgery.[11] In the present study, the greatest net increase in the nasolabial angle (11.2°) was observed in the Increase group. A previous study reported that an increase in the nasiolabial angle was correlated with a decrease of lower face height[17]; however, the mean increase in that sample was only 1.9°.

Decrease in lower face height. In most patients in the Decrease group, bimaxillary surgery was performed because of an excessive vertical dimension of the lower face, and surgery often involved maxillary posterior impaction and autorotation of the mandible. These surgical movements have been shown to be stable.[26,27] The surgical repositioning in this group was similar to that observed by Marşan et al,[17] and some of our findings correspond to their results: decrease of the mentolabial angle, decrease of upper lip thickness, and increase in lower lip thickness. In the present study, the decrease in the mentolabial angle was greatest in this group (18°), but the relative relapse was also greater (33%) compared to the other two groups. The significant associations between the vertical soft and hard tissue changes were similar to the findings of Marşan et al.[17] Two other bimaxillary studies without maxillary impaction reported significant associations and high ratios for the vertical changes.[10,12] In these studies, however, the mandibular setback was smaller than in our group, with no change in the face height, and the observation period was only 6 months.

Increase in lower face height. In the Increase group, both jaws rotated in a clockwise direction during surgery to correct severe skeletal discrepancies in conjunction with pronounced projection of the chin. To our knowledge there is no other study investigating soft tissue changes after this type of repositioning because of restricted sample sizes (as in the present material). A risk of compromised stability was previously reported by Proffit et al,[26] which may explain why large samples are difficult to collect. Compared to the No Change group, the magnitude of mandibular relapse relative to the surgical repositioning was only slightly higher in this group (30% vs 26% at Pg). Anterior relapse of the mandible was also related to counterclockwise rotation of both jaws. The weak association between AP soft and hard tissue changes for the upper lip in this group may be related to the presurgical presence of lip block in many of the patients.[16] The observation that the

Table 3. Pearson Correlation Coefficients and Ratios[a] for Soft to Hard Tissue Changes

Soft Tissue Landmark	Hard Tissue Landmark	No Change Group (n = 30)		Decrease Group (n = 40)		Increase Group (n = 11)	
		Correlation	Ratio (%)	Correlation	Ratio (%)	Correlation	Ratio (%)
Horizontal							
A′	A	0.57**	22	0.68**	52	0.19	−67
Ls	U1	0.49**	44	0.69**	41	0.15	−28
Li	L1	0.74**	79	0.76**	59	0.85**	74
B′	B	0.82**	69	0.92**	93	0.93**	70
Pg′	Pg	0.84*	49	0.90**	91	0.84**	64
Vertical							
Ls	U1	0.14	68	0.48**	23	0.49	77
Stm[s]	U1	0.09	53	0.59**	13	0.58	57
Li	L1	0.19	−4	0.45**	33	−0.65*	73
Me′	Me	0.09	46	0.62**	87	0.50	66

[a] Ratios are calculated from net soft tissue change (T1 to T6) relative to hard tissue surgical change (T1 to T2) (5% trimmed mean).

* $P < .05$; ** $P < .01$.

nasiolabial angle increased significantly and upper lip prominence was at the presurgical level in the long term has implications for planning of surgery. Thus, for patients with a retrusive upper lip, the long-term profile may benefit from a relatively greater maxillary advancement than mandibular setback, particularly in patients in whom the AFH is increased.

CONCLUSIONS

- Patients undergoing Class III bimaxillary surgery are morphologically heterogeneous and hence require different directions and amounts of surgical repositioning.
- The nasiolabial angle increased, particularly when face height was increased, and the mentolabial angle decreased, especially when face height was decreased.
- The upper lip thickness decreased and the lower lip thickness increased, irrespective of change in face height.
- When face height was increased, AP change of maxillary soft tissues was only minor and upper lip prominence returned to the presurgery level after 3 years. The mandibular soft tissues followed the skeletal relapse closely.
- Correlation coefficients for soft to hard tissue AP changes were statistically significant, except for maxillary variables when the face height was increased.
- Different patterns of soft tissue change depending on vertical surgical change and relapse tendencies should be taken into consideration when planning the relative amounts of maxillary advancement and mandibular setback.

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