Original Article

En Masse Retraction and Two-Step Retraction of Maxillary Anterior Teeth in Adult Class I Women

A Comparison of Anchorage Loss

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ABSTRACT

Objective: To compare the amount of anchorage loss of the maxillary posterior teeth and amount of retraction of the maxillary anterior teeth between en masse retraction and two-step retraction of the anterior teeth.

Materials and Methods: The sample consisted of 30 female adult patients with Class I malocclusion and lip protrusion who needed maximum posterior anchorage. The sample was subdivided into group 1 (n = 15, mean age = 21.4 years, en masse retraction) and group 2 (n = 15, mean age = 24.6 years, two-step retraction). Lateral cephalograms were taken before (T1) and after treatment (T2). Nine skeletal and 10 anchorage variables were measured, and independent *t*-test was used for statistical analysis.

Results: Although the amount of horizontal retraction of the maxillary anterior teeth was not different between the two groups, there was mild labial movement of the root apices of the upper incisors in group 2 at T2. There were no significant differences in the degree of anchorage loss of the maxillary posterior teeth between the two groups. Bodily and mesial movements of the upper molars occurred in both groups. Approximately 4 mm of the retraction of the upper incisal edges resulted from 1 mm of anchorage loss in the upper molars in both groups.

Conclusion: No significant differences existed in the degree of anchorage loss of the upper posterior teeth and the amount of retraction of the upper anterior teeth associated with en masse retraction and two-step retraction of the anterior teeth.

KEY WORDS: Anchorage loss; Lip protrusion; En masse retraction; Two-step retraction

INTRODUCTION

In the survey of chief complaints of orthodontic patients who visited the Department of Orthodontics at the Seoul National University Dental Hospital, lip protrusion was one of the major chief complaint in adults.[1] Extracting the first four premolars and retracting the anterior segments with maximum anchorage is the most common way to reduce lip protrusion and to straighten the patient's profile.[2] Accurate prediction of the amount of anchorage loss during extraction space closure is critical in determining both the treatment planning and the selection of appropriate mechanics.

For minimizing anchorage loss and maximizing tooth movement efficiency, Tweed[3–5] emphasized anchorage preparation as the first step in orthodontic treatment. Storey and Smith[6] advocated the use of light force values, and Begg[7] emphasized the advantages of differential force to produce the maximum rate of movement of teeth.

There have been controversies about how to achieve maximum anchorage preservation in the first premolar extraction cases. Proffit and Fields[8] recommended separate canine retraction for maximum anchorage, stating that this approach would allow the reaction force to be constantly dissipated over the large periodontal ligament area in the anchor unit. They acknowledged, however, that closing the space in two steps rather than in one would take nearly twice as

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long. Roth[9] also recommended separate canine retraction for maximum anchorage extraction cases but did not recommend it for moderate ones. Kuhlberg[10] described separate canine retraction as less taxing on anchorage because the two canines are opposed by several posterior teeth in the anchor unit.

On the other hand, Staggers and Germane[11] described anchorage as being taxed twice with a two-step retraction, as opposed to once with en masse retraction, pointing out that the posterior segment is unaware of knowing how many teeth are being retracted and merely responds according to the force system involved. Burstone[12] also questioned whether anchorage is better controlled with separate canine retraction. Although recent advances in orthodontic techniques, such as the orthodontic miniscrew, allow maximum anchorage and further simplify the procedure,[13–15] it is still necessary to know the difference in anchorage loss between en masse retraction and two-step retraction of the maxillary anterior teeth.

Despite controversies of anchorage preservation, there have been a few studies about comparing the two paradigms. The purpose of this study was to compare the degree of anchorage loss of the posterior teeth and the amount of retraction of the anterior teeth between en masse retraction and two-step retraction of the maxillary anterior teeth in Class I malocclusion patients with lip protrusion.

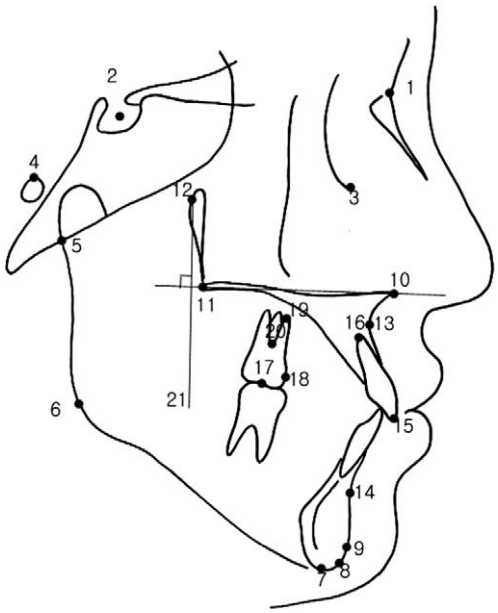


Figure 1. Landmarks and reference planes used for this study. 1, nasion (N); 2, sella (S); 3, orbitale (Or); 4, porion (Po); 5, articulare (Ar); 6, gonion (Go); 7, menton (Me); 8, gnathion (Gn); 9, pognion (Pog); 10, anterior nasal spine (ANS); 11, posterior nasal spine (PNS); 12, pterygoid point (Pt point); 13, subspinale (point A); 14, supramentale (point B); 15, upper incisor edge (U1E); 16, upper incisor root apex (U1A); 17, center of maxillary first molar crown on occlusal surface (U6C); 18, most mesial point of mesial surface of maxillary first molar crown (U6M); 19, mesiobuccal root apex of maxillary first molar (U6A); 20, furcation of maxillary first molar (U6F); 21, vertical reference plane through Pt point (tangent to palatal plane) (PTV).

MATERIALS AND METHODS

The initial sample consisted of 120 adult female patients with Class I malocclusion and lip protrusion who needed maximum posterior anchorage. According to the following criteria, final samples were selected from the initial ones:

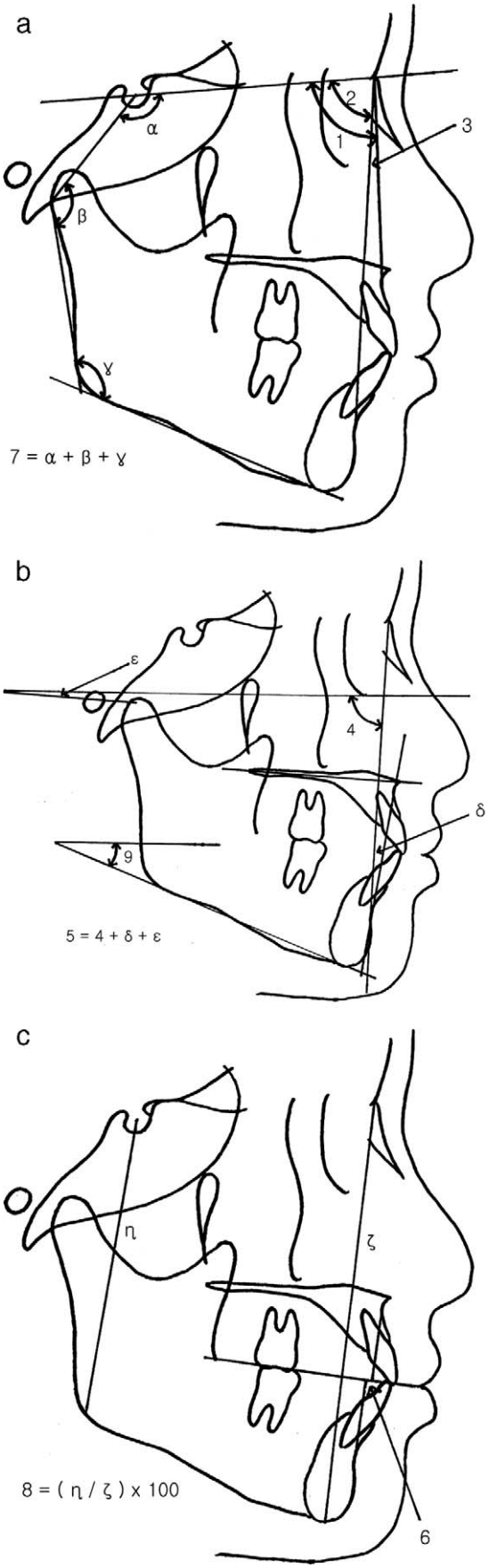
- women older than 17 years to eliminate potential influence of sex and growth;
- Class I malocclusion ($0° < ANB < 5°$) with normodivergent pattern ($22° < FMA < 31°$), lip protrusion (Ricketts' lower lip to esthetic line >2 mm), labioversed upper incisor (U1 to palatal plane $>105°$), and less than 4 mm crowding in each arch;
- four first premolars extraction cases; and
- use of a 0.022-inch straight wire appliance with Roth setup (fully bonded to second molars).

Thirty patients fulfilled the criteria and were allocated into group 1 ($n = 15$, mean age = 21.4 years, en masse retraction, using sliding mechanics, as described by Bennett and McLaughlin[16–18]) and group 2 ($n = 15$, mean age = 24.6 years, two-step retraction, with sliding mechanics for canine retraction and loop mechanics for the upper incisor retraction) after matching gender, age, skeletal, dental, and soft tissue relationships and treatment appliance. The open-type vertical loops made of 0.019-inch $\times$ 0.025-inch stainless steel wire with 8 mm height and 45° gable bends were used for the second stage of retraction of the upper four incisors. The loops were activated by 1 mm to produce a force of 150 g/side. Once the loops were deactivated, they were reactivated by 1 mm.

In the mandibular arch, six anterior teeth were retracted by en masse retraction with sliding mechanics in both groups. Space closure of the mandibular arch was performed simultaneously with that of the maxillary arch.

Lateral cephalometric radiographs were taken before (T1) and after treatment (T2). All lateral cephalograms were traced by one investigator. All traces were digitized by means of a graphic tablet (Wacom Co Ltd, Vancouver, BC, Canada) using a program developed for this study with an IBM-compatible computer. Linear measurements were in increments of 0.01 mm, and angular measurements were in increments of 0.01°.

Landmarks and reference planes used for this study were illustrated in Figure 1. Nine skeletal (Figure 2) and 10 anchorage variables (Figure 3) were measured. Error determination of cephalometric landmark



location and measurement was done. Six randomly selected sets of cephalograms were retraced and redigitized after the first set of recordings was obtained. Dahlberg's formula[20] was used to determine the error and standard deviation of the variables in each data set. The linear measurement error was found to be less than 0.43 mm, while the angular measurement error was less than 1.29°. Therefore, the first measurement was used for this study.

Comparison of skeletal variables between groups 1 and 2 at T1, the time of retraction between groups 1 and 2, anchorage variables between groups 1 and 2 at T1 and T2, and changes of anchorage variables during T2 and T1 were evaluated by independent *t*-tests.

RESULTS

Although there was no significant difference in skeletal horizontal variables between group 1 and group 2 at T1, skeletal vertical variables such as the Björk sum ($P < .05$), facial height ratio ($P < .05$), and FMA ($P < .05$) in group 2 showed a relatively more hypodivergent pattern than in group 1 (Table 1).

Although the mean time of retraction in group 2 was longer than in group 1, there was no significant difference in the time of retraction between groups 1 and 2 (Table 2).

The anchorage variables at T1 showed no significant differences between group 1 and group 2 (Table 3). At T2, there were also no significant differences between the two groups except U1A-Hor (Table 3). U1A-Hor showed that the upper incisor root apex in group 2 was farther from the PTV than in group 1 ($P < .05$; Table 3).

Since there was mild labial movement of the root apices of the upper incisors in group 2 at T2, the amount of change in inclination of the upper incisor (U1 to PP; $P < .05$) and the horizontal position of the upper incisor apex (U1A-Hor) showed a significant difference from group 1 at $P < .001$ (Table 3).

Although there was no significant difference in the amount of change in the horizontal position of the upper incisal edge (U1E-Hor) between the two groups, the amount of change in the vertical position of the upper incisal edge (U1E-Ver) showed a significant difference ($P < .05$; Table 3). The reason could be due

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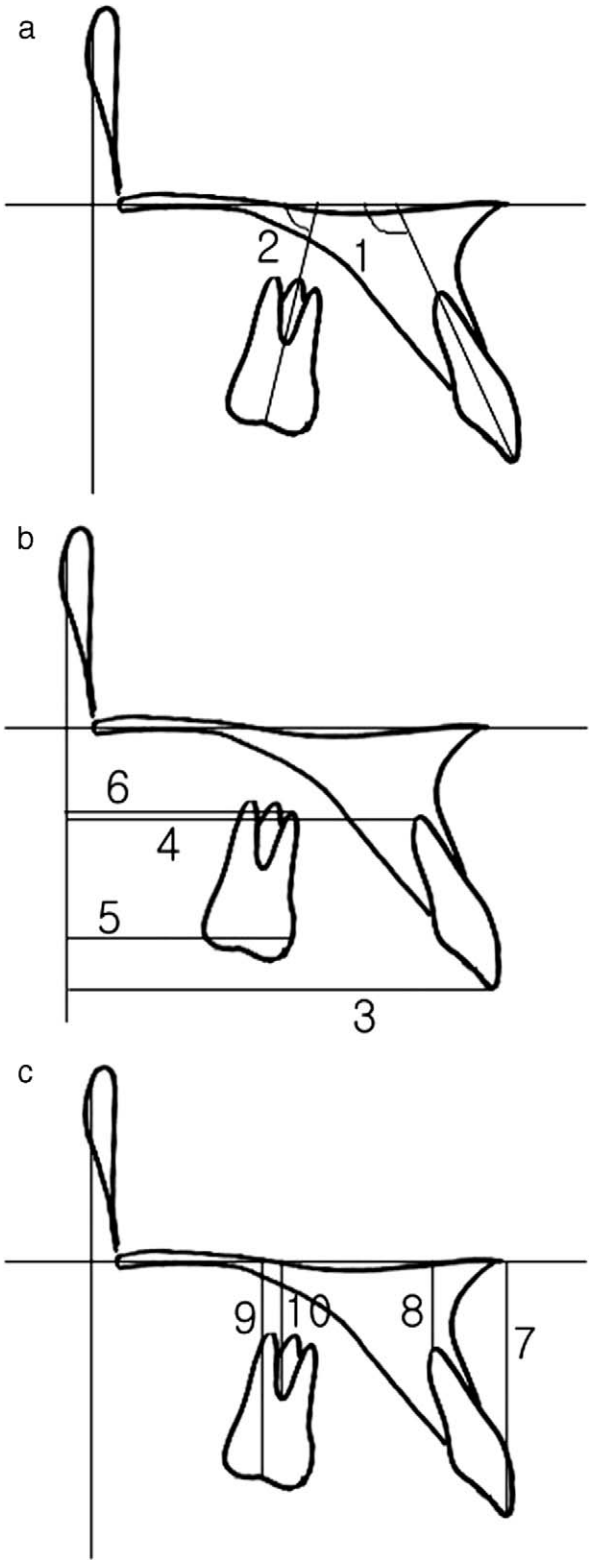
Figure 2. (a–c) Skeletal variables. Skeletal horizontal variables: 1, SNA; 2, SNB; 3, ANB; 4, facial angle (N-Pog to Frankfort horizontal plane); 5, anteroposterior dysplasia indicator (APDI)[19]; 6, Wits appraisal. Skeletal vertical variables: 7, Björk sum; 8, facial height ratio (posterior facial height/anterior facial height 100×); 9, Frankfort mandibular plane angle (FMA).



to downward movement of the upper incisal edge of group 2, which was originally positioned more superiorly. However, the vertical position of the upper incisal edge of group 1 was well maintained (Table 3).

There were no significant differences in the amount of changes in the upper molar such as U6 to PP, U6M-Hor, U6A-Hor, U6C-Ver, and U6F-Ver between groups 1 and 2 (Table 3). Bodily and mesial movements of the upper molars were found in both groups (Table 3). Approximately 4 mm of the retraction of the upper incisal edges resulted from 1 mm of anchorage loss in the upper molars in both groups (Table 3).

DISCUSSION

This study was performed to determine whether two-step retraction provides better anchorage preservation than en masse retraction. To exclude the influence of skeletal and dental factors, patient records with Class I malocclusion, lip protrusion, normodivergent skeletal patterns, labioversion of the upper incisors, and less than 4 mm crowding in each arch were adopted.

Although there was no significant difference in skeletal horizontal variables between two groups at T1, there were significant differences in skeletal vertical variables (Björk sum, facial height ratio, FMA, $P < .05$) by chance (Table 1). This means that group 2 showed a relatively greater hypodivergent pattern within the normodivergent skeletal pattern compared to group 1. Since it is known that patients with a hypodivergent facial type have stronger natural anchorage than those with a hyperdivergent one,[21] group 2 might have a better tendency of natural anchorage preservation than group 1. However, the fact that there was no difference in anchorage loss of the upper molar (Table 3) suggests that two-step retraction takes only more time to close the extraction space without advantage of anchorage preservation.

During retraction, both groups showed bodily and

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Figure 3. (a–c) Anchorage variables. (a) 1, U1 to PP (°); 2, U6 to PP (°), (b) 3, U1E-Hor: the horizontal distance from U1E to PTV (mm); 4, U1A-Hor: the horizontal distance from U1A to PTV (mm); 5, U6M-Hor: the horizontal distance from U6M to PTV (mm); 6, U6A-Hor: the distance from U6A to PTV (mm), (c); 7, U1E-Ver: the vertical distance from U1E to palatal plane (mm); 8, U1A-Ver: the vertical distance from U1A to palatal plane (mm); 9, U6C-Ver: the vertical distance from U6C to palatal plane (mm); 10, U6F-Ver: the vertical distance from U6F to palatal plane (mm). U1 indicates upper incisor; PP, palatal plane; U6, long axis of the upper first molar through the center of the upper first molar crown on the occlusal surface (U6C) and furcation of the upper first molar (U6F); U1E, upper incisor edge; U1A, root apex of the upper incisor; U6M, most mesial point of mesial surface of the upper first molar crown; and U6A, mesiobuccal root apex of the upper first molar.

Table 1. Comparison of Skeletal Variables Between Groups 1 and 2 at T1[a]

	Group 1		Group 2		
Skeletal Variable	x̄	SD	x̄	SD	Significance
SNA	82.59	3.10	83.93	2.21	NS
SNB	79.77	3.13	80.97	2.87	NS
ANB	2.83	2.41	2.97	1.43	NS
Facial angle	87.68	3.73	88.64	2.66	NS
APDI	85.19	4.99	85.20	3.16	NS
Wits appraisal	−1.89	3.10	−0.05	2.14	NS
Björk sum	395.43	3.17	391.66	3.03	*
Facial height ratio	66.22	2.94	68.93	3.01	*
FMA	26.95	4.03	23.50	2.68	*

[a] Independent *t*-test. NS indicates not significant; APDI, anteroposterior dysplasia indicator; and facial height ratio, posterior facial height/anterior facial height 100×.

* $P < .05$.

Table 2. Time of Retraction (Years) Between Groups 1 and 2[a]

Group 1		Group 2		
x̄	SD	x̄	SD	Significance
0.93	0.36	1.31	0.71	NS

[a] Independent *t*-test. NS indicates not significant.

mesial movement of the upper molars (U6 to PP, U6M-Hor, U6A-Hor; Table 3). Since maximum posterior anchorage includes 100% anterior retraction (no posterior anchorage loss) to 75% anterior retraction (25% of space closure from posterior anchorage movement),[22] the amounts of anchorage loss were 2.0 mm in group 1 and 1.9 mm in group 2. These values are less than 25% when considering the premolar extraction space as 8.3 to 8.4 mm. Therefore, it seemed to be acceptable as maximum posterior anchorage.

The upper incisors were retracted in group 1 with a combination of tipping and bodily movement (Table 3). However, the upper incisor in group 2 moved in a relatively uncontrolled tipping manner (U1 to PP, $P < .05$; U1A-Hor, $P < .001$; Table 3) and showed a resultant downward movement of the upper incisal edge (U1E-Ver, $P < .05$; Table 3). It is known that a tipping movement of the upper anterior teeth is easier and requires less anchorage of the upper posterior teeth than bodily movement.[23,24] In view of that, group 2 might have an advantage over group 1 in terms of anchorage preservation. However, the result that there was no difference in anchorage loss of the upper molar (Table 3) suggests that the anchorage loss in group

Table 3. Comparison of Anchorage Variables Between Groups 1 and 2 at T1 and T2 and Changes in Anchorage Variables During Treatment (T2–T1)[a]

Stage	T1					T2					T2–T1				
Anchorage	Group 1		Group 2			Group 1		Group 2			Group 1		Group 2		
Variable	x̄	SD	x̄	SD	Sig	x̄	SD	x̄	SD	Sig	x̄	SD	x̄	SD	Sig
U1 to PP	123.41	4.61	125.75	4.19	NS	108.84	6.83	105.15	5.15	NS	−14.57	5.23	−20.60	4.43	*
U6 to PP	83.55	3.92	83.52	5.49	NS	84.27	4.66	83.13	4.15	NS	0.72	3.78	−0.39	2.76	NS
U1E-Hor	56.70	2.21	57.99	3.68	NS	50.39	3.31	51.47	3.88	NS	−6.30	1.81	−6.52	1.27	NS
U1A-Hor	44.07	2.54	44.85	3.66	NS	42.98	2.51	45.49	3.11	*	−1.09	1.10	0.64	0.99	**
U6M-Hor	27.43	2.19	28.66	3.41	NS	29.46	2.38	30.54	3.40	NS	2.03	0.77	1.88	0.64	NS
U6A-Hor	25.64	1.89	26.83	2.47	NS	27.59	1.92	28.75	2.92	NS	1.95	0.92	1.92	0.66	NS
U1E-Ver	29.14	2.49	27.55	2.03	NS	29.66	2.41	29.18	2.31	NS	0.52	1.14	1.63	1.12	*
U1A-Ver	9.91	2.14	9.29	1.69	NS	8.17	2.57	7.66	1.99	NS	−1.75	1.02	−1.63	0.73	NS
U6C-Ver	24.21	1.67	23.75	1.24	NS	24.41	1.82	24.14	1.24	NS	0.20	0.67	0.39	0.68	NS
U6F-Ver	13.14	1.94	12.71	1.04	NS	13.37	2.02	13.00	1.13	NS	0.23	0.65	0.29	0.80	NS
U1 to U6 ratio	—	—	—	—	—	—	—	—	—	—	3.93	2.53	4.02	2.17	NS

[a] Independent *t*-test. NS indicates not significant; sig, significance; U1, upper incisor; PP, palatal plane; U6, long axis of the upper first molar through the center of the upper first molar crown on the occlusal surface (U6C) and furcation of the upper first molar (U6F); U1E, upper incisor edge; root apex of the upper incisor; U6M, most mesial point of the mesial surface of the upper first molar crown; U6A, mesiobuccal root apex of the upper first molar; U1 to U6 ratio [(ΔU1E-Hor)/(ΔU6M-Hor) × (−1)], the amount of retraction of the upper incisal edges according to every 1-mm anchorage loss of upper molars.

* $P < .05$; ** $P < .001$.

2 continuously occurred during separate canine retraction and following incisor retraction with a forfeit of the advantage of anchorage preservation.

The fact that approximately 4 mm of the retraction of upper incisal edges resulted from 1 mm of anchorage loss of the upper molars in both groups (Table 3) may be helpful when diagnosing lip protrusion patients and estimating soft tissue change for them. If, in lip protrusion cases, more retraction of the anterior teeth is needed than the predicted amounts, additional anchorage reinforcement with headgear or orthodontic miniscrews would be necessary.

CONCLUSIONS

- No significant differences existed in the degree of anchorage loss of the upper posterior teeth and the amount of retraction of the upper anterior teeth associated with en masse retraction and two-step retraction of the anterior teeth.
- When choosing retraction mechanics, it is necessary to consider additional aspects such as the inclination and vertical position of the anterior teeth rather than anchorage loss.

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