EIGHTEEN YEARS OF RESEARCH AT ILLINOIS (Cont.)

As you might imagine the furor over the extraction question had not left us untouched. We had investigated a number of the procedures and the claims made by the proponents of this method, such as diagnosis based on the axial relation of the lower incisor to the mandible; the retraction of these teeth to improve esthetics, and so forth, and our findings had appeared as clinical papers, principally in the collection known as the "Extraction Panel." * Most of the claims were disproved, it being shown that the axial inclination of the lower incisor exhibited, in the normal, the same range as any other characteristic and the retraction of the incisor having been shown to be accompanied frequently by a labial movement of the root apices and mesial movement of the molars of far greater extent. Follow-up records of two cases had shown that the incisor tended to return to its previous inclination. We were naturally interested to know what post-treatment changes would show and we accordingly assigned this problem to two students. One was to study a group of cases treated by extraction in the clinic and the other was to study post-treatment changes in cases treated without extraction. The extraction cases were studied by Dr. Harvey Cole.

Certain Results of Extraction In the Treatment of Malocclusion[1]

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Extraction of teeth as an aid in the treatment of malocclusion is one of the oldest and most controversial subjects in orthodontic history. Arguments on this matter reached their peak with the Edward H. Angle-Calvin S. Case controversy about forty-five years ago. The introduction, by Angle, of his classification of malocclusion in 1899 and his subsequent promulgation of the idea of normal occlusion, placed the extraction of teeth as an orthodontic aid in the light of reprehensible practice. The researches of the past twenty years have revealed limitations to orthodontic procedures not previously realized and, as a result, the question of extraction has once more gained prominence.

The orthodontic clinician and the research investigator have come to attach great importance to the axial positions of the teeth. The incisor and molar teeth have attracted the greatest amount of attention. This interest stems from the idea advanced by Tweed[18] that mandibular incisors should stand upright in relation to the body of the mandible if stability of result is to be expected.

Margolis[13] related the long axis of the mandibular incisor to the mandibular plane. (This plane is tangent to the inferior border of the mandible.) He recognized the fact that this relationship could be changed by orthodontic treatment. A study of the changes in this incisor-mandibular plane

*Brodie, A. G. et al. Orthodontics: its objectives, past and present. Am. Jnl. Orth. + Orl. Surg. 30: 401. 1944.

[1] Based on a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, University of Illinois, 1947.

angle was made by means of standardized cephalometric x-rays. Margolis advanced the idea that the crowding of the mandibular incisors which frequently followed treatment by arch expansion was not due to the eruption of the third molars but to the 'straightening up'' of these lower anterior teeth. One case was cited in which this angle was changed from 101 degrees to 116.5 degrees as a result of treatment. One year after all retention had been removed, the angle measured 106 degrees.

Brodie,[3] using cephalometric x-rays, analyzed the treatment of two cases of malocclusion involving extraction. By superpositioning serial tracings, he demonstrated that the forward movement of the molars was considerably greater than the backward movement of the incisors and that, although these latter teeth had been markedly uprighted during treatment, they tended to return to their original inclinations following treatment.

Noyes, Rushing, and Sims[15] studied normal occlusions in dried skulls and in the living. The inclinations of mandibular incisors were measured from cephalometric x-rays but no conclusions were drawn because of the limited amount of material.

Speidel and Stoner[16] recorded variations of axial inclinations of the mandibular incisor. Tracings of lateral head roentgenograms were made and the long axis of the mandibular central incisor to a line tangent to the lower border of the mandible were related. Their patients exhibited superior if not ideal dental occlusal relationships.

The studies of Brodie, Noyes et al, and Speidel all demonstrated the fact that the axial inclination of the lower incisors is an individual characteristic which shows a great range of variability.

In their appraisal of orthodontic result, Brodie, Downs, Goldstein, and Myer[6] analyzed a group of treated cases consisting of all classes of malocclusion. Although it was not the purpose of the paper to show movement of teeth as a result of orthodontic treatment, it was observed that the axial inclinations of teeth, disturbed by orthodontic management, tended to return to their original positions after treatment.

Cephalometric x-rays were used by Downs[7] to appraise the tooth movements which were accomplished when mandibular arch length was increased by treatment. Superpositioning was done on the gonial angle, posterior border of the ramus and inferior border of the mandible. Changes in position of roots and crowns of incisors and molars and alterations in their axial inclinations were recorded.

Fischer [9], [10], [11] devised a method for comparing the position and axial inclination of the maxillary and mandibular incisors before and after treatment. By means of oriented plaster casts, oriented photographs, and mandibular roentgenograms, an appraisal of tooth movements in one case was made. Four bicuspids were extracted and the case was treated with the Edgewise appliance. It was observed that the closure of space created by extraction was obtained by posterior and lateral movement of anterior teeth and forward movement of molars. It was pointed out that, after treatment, the mandibular incisors were uprighted from their original positions with respect to the Frankfort plane and that their roots appeared well imbedded in bone.

In few of the above investigations were the observations carried beyond the end of treatment. The purpose of the present study was to enlarge the scope by the study of a large number of cases and to extend it over a longer period of time for the purpose of determining what, if any, changes occurred following the removal of all retention.

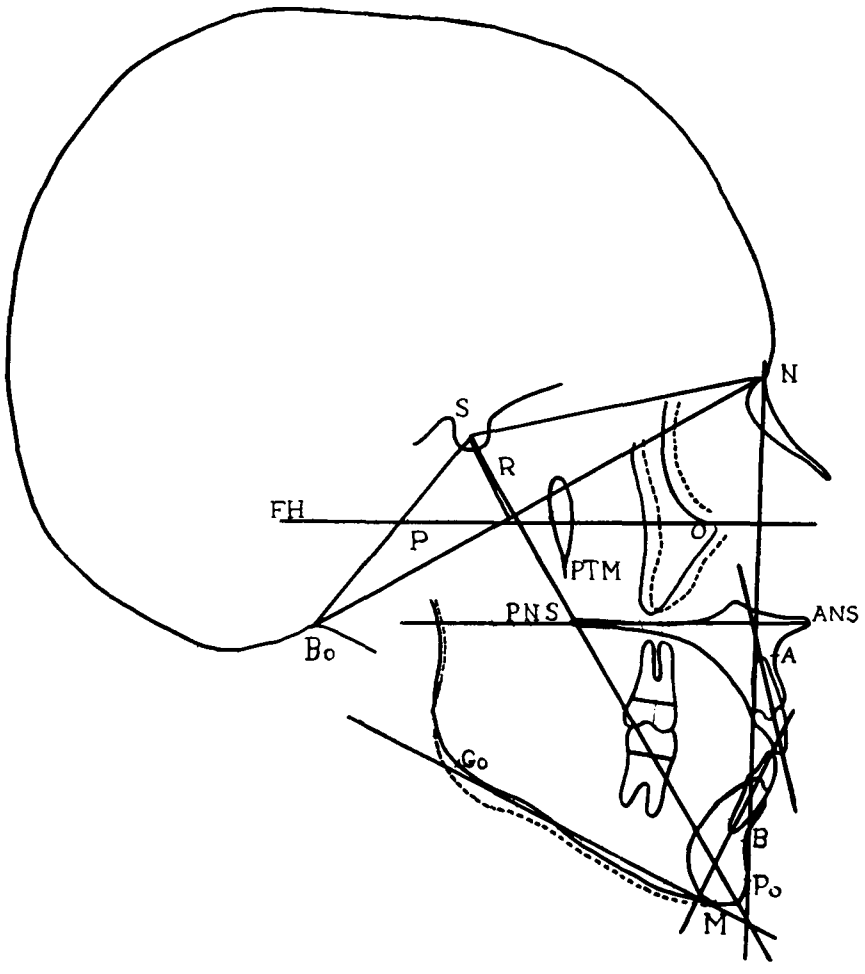

FIG. 1. Planes and landmarks used in study.

METHOD

Twenty-one cases of malocclusion were analyzed according to the techniques developed by Brodie[4], Downs[8], and Broadbent[2]. The cases, all treated with the Edgewise Arch mechanism, were collected from the files of the Department of Graduate Orthodontia, University of Illinois and from three private practices. In every case, four first bicuspids had been extracted to expedite treatment.

Complete tracings were made from cephalometric headplates taken at the beginning of treatment, at the end of treatment, and subsequent to the removal of all retention. All cases had been out of retention for at least one year.

In order to analyze the behavior of the mandibular incisors and the maxillary and mandibular first permanent molars, the following planes were established: (Fig. 1)

1. The mandibular plane: a line tangent to the inferior border of the mandible.
2. The palatal plane: a line connecting the anterior and posterior nasal spines. (ANS-PNS)
3. A line drawn through the long axis of the left mandibular incisor connecting the incisal tip and the midpoint of the root apex. This line was extended to intersect the mandibular plane.
4. A line drawn through the long axis of the left mandibular first permanent molar by connecting a series of midpoints on this tooth. This line was extended to intersect the palatal plane.
5. A line was drawn through the long axis of the left maxillary first permanent molar by connecting a series of midpoints on this tooth. This line was extended to intersect the palatal plane.

In the maxilla, the palatal planes and points ANS of serial tracings were superposed and in the mandible, the mandibular planes and cross sections of the symphyses of serial tracings were superposed. Brash[1], Hunter[12], and Nance[14] have stated that the amount of forward growth which takes place anterior to the six year molar after seven years of age is very slight. The present method of superpositioning was for the purpose of minimizing the variable introduced by anteroposterior growth of the jaws.

Changes in anteroposterior dimensions of the total mandible were recorded at the chin point and at point B by superpositioning serial tracings on the mandibular planes, gonial angles, and posterior borders of the rami. Point B is the most anterior point on the plane which demarcates the alveolar process from the true body of the mandible.

Changes in the anteroposterior dimensions of the maxilla were measured at point A by superpositioning serial tracings on the pterygomaxillary fissures and palatal planes. Point A is the most anterior point on the plane which demarcates the maxillary alveolar process from its base. The gonial angle and the pterygomaxillary fissure were used as bases of measurements because Brodie[5] has demonstrated the constancy of these anatomical landmarks during the growth process.

Changes in the overbite were recorded by measuring distances between the incisal edges of maxillary and mandibular central incisors with the teeth in occlusion.

The following readings were tabulated:

Angular

1. Angle formed by the long axis of the mandibular left central incisor and the mandibular plane.
2. Angle formed by the long axis of the mandibular left first permanent molar and the mandibular plane.
3. Angle formed by the long axis of the maxillary left first permanent molar and the palatal plane.

Linear

1. The anteroposterior linear change of the mandibular left central incisor determined by superposing serial tracings on the cross sections of the mandibular symphyses and the mandibular planes. Changes in position of the crown and root apex were measured along planes parallel to the mandibular plane.

2. The anteroposterior linear change of the mandibular left first permanent molar determined by superposing serial tracings on the cross sections of the mandibular symphyses and the mandibular planes. Changes in position of the crown and root apices were measured along planes parallel to the mandibular plane.
3. The anteroposterior linear change of the maxillary left first permanent molar determined by superposing serial tracings on the palatal plane with point A registered. Changes in position of the crown and root apices were measured along planes parallel to the palatal plane.

Angles were measured with a standard protractor to 0.5 degree and linear change to 0.5 mm.

Findings

The Mandibular Central Incisors (Tables I and II and Figs. 2, 3, 4)

Root Apex:

With but one exception, all mandibular central incisor root apices either held their original positions or were moved posteriorly as a result of treatment. Twelve cases showed no movement. Eight cases exhibited posterior movement of roots. All of these eight exhibited relative stability of these new positions in the third headplate.

Crown:

Posterior movements of mandibular incisor crowns were observed in nineteen cases. Thirteen cases showed stability of these movements. In four cases, there were tendencies for crowns to return toward their original positions. In the remaining two cases, movements continued in a posterior direction.

Angular Inclination:

In eleven cases, the angular inclinations of the mandibular incisors tended to return toward their original positions after all retention had been removed. (Fig. 2) In six cases, results remained stable. (Fig. 3) In the four remaining cases, the movement tendencies continued in the direction of the orthodontic treatment. (Fig. 4)

TABLE I
RESPONSE OF AXIAL INCLINATION OF MANDIBULAR CENTRAL INCISORS TO TREATMENT AND THEIR BEHAVIOR SUBSEQUENT TO RETENTION

Response to Treatment	*No. Cases*	*Behavior Subsequent to Retention*	
No Change in Axial Inclination	1	Stable	
Change in Axial Inclination	20	Stable	5
		Tended to Return	11
		Moved in Direction of Treatment	4

TABLE II
TRANSLATORY MOVEMENT OF MANDIBULAR CENTRAL INCISORS TO TREATMENT AND THEIR BEHAVIOR SUBSEQUENT TO RETENTION

	No. Cases	*Behavior Subsequent to Retention*	
No Movement of Root	12	Stable	10
		Moved Posteriorly	2
Posterior Movement of Root	8	Stable	
Anterior Movement of Root	1	Moved Posteriorly	
No Movement of Crown	1	Slight Posterior Root Movement	
Posterior Movement of Crown	19	Stable	10
		Tended to Return	6
		Moved in Direction of Treatment	3
Anterior Movement of Crown	1	Moved in Direction of Treatment	

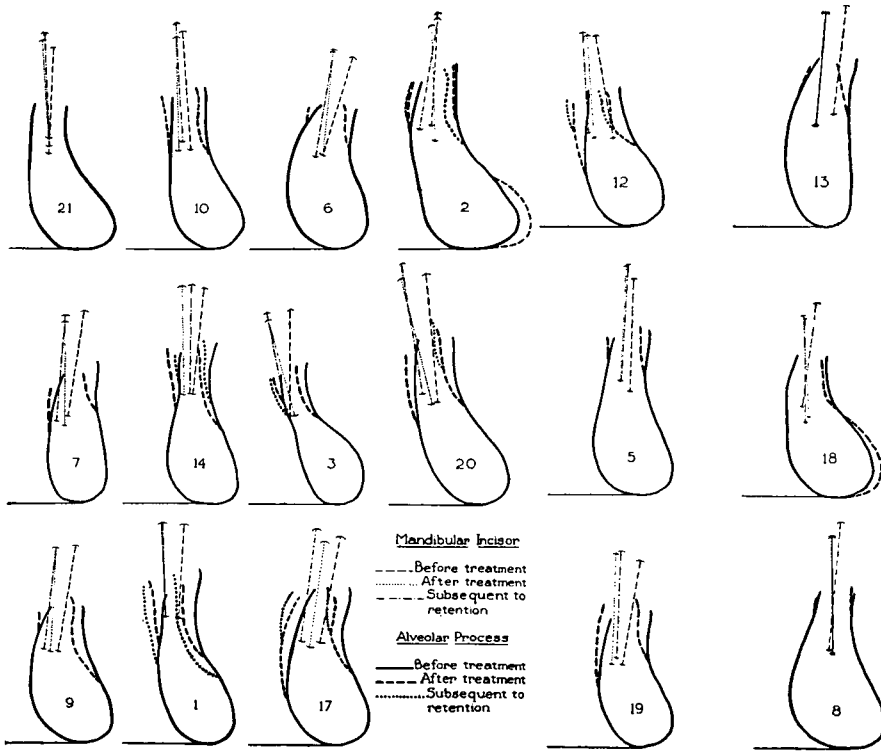

FIG. 2

Tracings of cross sections at the mandibular symphyses showing cases whose mandibular incisor axial inclinations tended to return to original inclinations subsequent to retention.

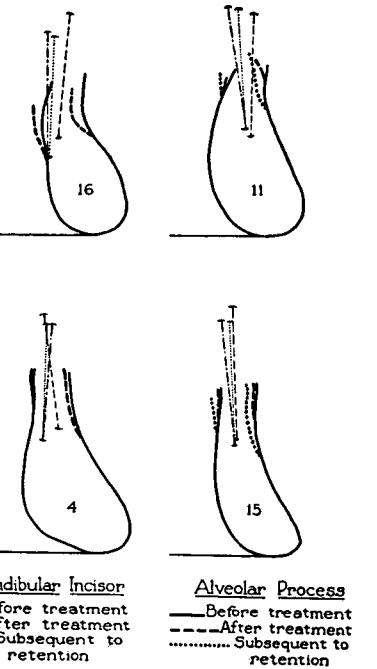

FIG. 4

Tracings of cross sections at the mandibular symphyses showing cases whose mandibular incisor axial inclinations continued to move in direction of treatment subsequent to retention.

FIG. 3

Tracings of cross sections at the mandibular symphyses showing cases whose mandibular incisor axial inclinations remained stable subsequent to retention.

TABLE III
TRANSLATORY MOVEMENT OF MAXILLARY FIRST PERMANENT MOLARS IN RESPONSE TO TREATMENT

Response	*No. Cases*
No Anterior Crown or Root Movement	3
Anterior Crown and Root Movement	16
Anterior Root Movement Only	0
Anterior Crown Movement Only	2

TABLE IV
BEHAVIOR OF AXIAL INCLINATION OF MAXILLARY FIRST PERMANENT MOLAR SUBSEQUENT TO RETENTION

Response to Treatment	*No. Cases*	*Stable*	*More Mesial Tip*
Mesial Tip	14	5	9
Distal Tip	0	—	—
No Tip After Anterior Movement	4	0	4
No Anterior Crown or Root Movement	3	3	0

TABLE V
TRANSLATORY MOVEMENT OF MANDIBULAR FIRST PERMANENT MOLARS IN RESPONSE TO TREATMENT

Response	*No. Cases*
No Anterior Crown or Root Movement	0
Anterior Crown and Root Movement	17
Anterior Root Movement Only	2
Anterior Crown Movement Only	2

TABLE VI
BEHAVIOR OF AXIAL INCLINATION OF MANDIBULAR FIRST PERMANENT MOLAR SUBSEQUENT TO RETENTION

Response to Treatment	*No. Cases*	*Stable*	*Tendency to Return*
Mesial Tip	4	2	2
Distal Tip	13	4	9
No Tip After Anterior Movement	4	4	0

The Mandibular First Permanent Molar (Table VI)

All cases exhibited some anterior movement of mandibular molars as a result of treatment. Seventeen cases involved anterior movements of both crowds and roots (Table V). Eleven exhibited greater anterior movements of roots than crowns. Seven of these showed a return or a tendency to return to original inclinations subsequent to retention. The remaining four of this group showed mandibular molars to retain their distal inclinations. Four cases show bodily anterior movements and a stability for these positions subsequent to retention. In two cases, slightly greater anterior movements of crowns than roots were observed. This represents bodily movement with mesial tipping. These positions appeared stable in the third headplate.

Two cases showed anterior movements of crowns only. The roots came forward after retention with tendencies to return to original inclinations.

Two cases exhibited anterior root movements only. The crowns came forward after retention, denoting a return to original inclinations.

The Maxillary First Permanent Molar

Some anterior movements of maxillary first molars were involved in eighteen cases (Table III). Sixteen cases showed both crown and root anterior movements. Twelve of these involved greater movement of crowns and eight of these twelve continued to tip more mesially after retention. (Table IV).

TABLE VII
BEHAVIOR OF OVERBITE AFTER TREATMENT AND SUBSEQUENT TO RETENTION

	After Treatment	*Subsequent to Retention**
Increase	8	14
Decrease	7	3
No Change	6	4

* As compared to the overbite before treatment was instituted

TABLE VIII
BEHAVIOR OF THE MANDIBULAR INCISOR—MANDIBULAR PLANE ANGLE IN DEGREES

Case No.	*Before Treatment*	*After Treatment*	*Subsequent to Retention*
1.	93	89	89.5
2.	93	89	98
3.	90	74.5	78
4.	84	89	92
5.	92	92	91.5
6.	105	94	98
7.	97	90	94
8.	96	91	91
9.	99	92.5	95
10.	86	88	87.5
11.	90	84.5	80
12.	80.5	88	88
13.	97	95.5	95
14.	95	87	90
15.	87.5	87	84
16.	94	92	90.5
17.	102	99	99.5
18.	97	88.5	88.5
19.	99	95	95
20.	85	75	80.5
21.	94	86	87

The Behavior of the Overbite

The overbite increased after retention in 14 cases. The mandibular plane angle decreased in every case (Table VII). Seven cases exhibited overbites which had been reduced by treatment. Five of these involved an increase in the mandibular plane angle. Two showed a decreased mandibular plane angle, perhaps due to depression of mandibular incisors. All of the seven cases in which overbite reduction was accomplished by treatment exhibited a relapse of this corrected overbite subsequent to retention. In six of these seven cases, the mandibular plane angles returned to or became less than the original measurements.

Effect of Orthodontic Treatment Upon Bone (Figs. 2, 3, 4)

Remodeling of the alveolar process in the direction of the tooth movement was observed in most cases. Basal bone was unaffected.

Discussion

This study was undertaken for the purpose of investigating only one of a number of factors that bear on the question of extraction as a part of orthodontic therapy. It was directed toward a determination of the changes that take place in the positions of the incisor and molar teeth. Such important factors as the balance of the facial musculature, the skeletal pattern, and the relationship of the denture to the cranium were not analyzed.

The closure of the space created by the extraction involved the backward movement of the incisors and the forward movement of the molars. The movement of the incisors exceeded that of the molars in twenty-five per cent of the cases studied. However, there were fifty per cent of the cases that exhibited greater forward movement of molars than backward movement of incisors.

The axial inclinations of the mandibular incisors that exhibited the tendencies to return to their original inclinations reverted an average of thirty-four per cent of the distances they had been moved by treatment. However, while there is a definite tendency for the mandibular incisors to return to their orginial inclinations, treatment with extraction was successful in establishing a more vertical position of these incisors and their alveolar processes in relation to their mandibular planes.

The question of overbite has not been given the attention that it deserves in the extraction controversy, yet, a deep overbite is considered an undesirable condition.

Brodie[5] pointed out the stability of the mandibular plane. He stated that growth does not disturb the angular relationship of the inferior border of the mandible with the cranial base. It was observed in this study that as the overbite was reduced by treatment, the Frankfort-Mandibular plane angle was increased. The reduction of the overbite was accomplished by depression of the mandibular incisors in some cases and by distal tipping of the molars in others.

Sixty-two per cent of the cases exhibited greater overbite subsequent to retention than that which was present before treatment was instituted. The increase in the overbite was probably due to the more forward positioning of the molars. This would permit greater closure of the jaws before the molars came into occlusion. It is possible that this increased overbite created a force operating between the maxillary and mandibular incisors. Provided the maxillary incisors retained their positions, the force would tip the mandibular incisors posteriorly. This behavior could explain the continued posterior movements of the mandibular incisor crowns which was observed in some cases subsequent to retention. As the overbite correction relapsed subsequent to retention, the mandibular plane returned to its original relationship with Frankfort. Thompson[17] observed the importance of the physiological rest position of the mandible and the free way space. The mandible is considered a link in the chain of muscles which antagonize the post-cervical musculature. If the free-way space is exceeded through the opening of the bite, the original rest position will be reestablished because it is governed by muscular balance. It is possible that the return of the mandible to its rest position was responsible in some cases for the relapse tendency of the overbite reduced through treatment.

Several cases had mandibular incisor crowns which tended to return to their original positions after having been moved posteriorly by treatment. These were associated with mandibular molars whose long axes had been tipped backward by treatment. Subsequent to retention, these molars returned to their original axial inclinations through anterior movements of their crowns. Granted that the musculature exerted a profound influence upon the orthodontically moved teeth with its tendency to return the denture toward the original positions, the possibility was present that the forward positioning of the mandibular molar crowns subsequent to retention was associated with an increase in procumbency of the mandibular incisors.

Many cases in which stability of mandibular molar crowns was observed subsequent to retention exhibited stability of mandibular incisors after retention.

This study bears out the observations made by Brodie et al.[6] with regard to bone changes due to orthodontic treatment. Fig. 2, 3, and 4 clearly illustrate the fact that only the alveolar process can be modified by treatment; the basal structure remains unmodified.

Summary

1. Closure of the space created by extraction is accomplished by anterior movement of the molars and posterior movement of incisors.
2. Posterior movement of mandibular incisors can involve either the crown alone or the crown and the root.
3. A strong tendency seems to be present for the axial inclination of the mandibular incisor to return toward its original relationship with the mandibular plane after retention has been removed.
4. There is an indication that the forward positioning of the mandibular first permanent molar crown subsequent to retention has some association with an increase in procumbency of mandibular incisors. Stability of position of mandibular molar crown seems to accompany stability of mandibular incisors after retention.
5. Treatment involving extraction tends to increase the overbite.
6. Overbites reduced by treatment tend to return.
7. An increase in the overbite involves a decrease in the mandibular plane angle. This increased overbite does not, however, permanently alter the physiological rest position of the mandible.

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