Original Article

Treatment effects on Class II division 1 high angle patients treated according to the Bioprogressive therapy (cervical headgear and lower utility arch), with emphasis on vertical control

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Abstract

Objective: This study investigated vertical control and the effects of orthodontic treatment on dolicofacial patients, using cervical headgear (CHG) and lower utility arch. **Methods:** Cephalometric assessment of 26 dolicofacial patients with Class II, division 1, and mean age of 114 months. Orthodontic treatment involved the use of cervical headgear (CHG) in the maxillary arch, lower utility arch in the mandibular arch until normal occlusion of the molars was obtained and finished in accordance with Bioprogressive Therapy, with a mean duration of 56 months. The values of FMA, SN.GoGn, ANB, Fg-S, S-FPm, maxillary length, mandibular length, posterior facial height (PFH), anterior facial height (AFH), facial height index (FHI), occlusal plane angle (OPA), palatal plane angle (PPA), total chin (TC), upper lip (UL) and Z angle were evaluated. **Results:** The results showed that treatment promoted stability of the mandibular, occlusal and palatal planes. Anteroposterior correction of the apical bases occurred, verified by the significant reduction in the variable ANB. The maxilla presented slight anterior displacement and increase in the anteroposterior dimension. The mandible presented improvement in its position in relation to the cranial base and its anteroposterior dimension increased significantly. The posterior and anterior facial heights remained in equilibrium, with no significant alteration in FHI. The tegumental profile presented significant improvement. **Conclusion:** The treatment performed produced correction of the apical basis with control of the horizontal planes and facial heights, and was effective for vertical control.

Keywords: Extraoral cervical traction appliances. Cephalometry. Orthodontics. Vertical control. Malocclusion. Class II, division 1.

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INTRODUCTION

The vertical growth pattern of Class II represents an unfavorable factor, since divergence from the horizontal plane generally indicates a mandible positioned more downwards and backwards, accentuating the skeletal and dental discrepancy of this malocclusion,[7,17] making vertical control in the palatal, occlusal and mandibular planes essential, as well as of the posterior and anterior facial heights during dental treatment.[6,8,24]

The application of various forms of treatment and mechano-therapy can be found in the dental literature, but the main objective of any strategy should center on reestablishment of the physiological functions, whenever possible normalizing the dentoalveolar and skeletal positions, and consequently providing a more harmonious profile to the patient.

One of the orthodontic appliances available for the correction of Class II, division 1 is the extraoral cervical traction appliance (CHG) developed by Silas Kloehn in 1947,[12] much used and studied during various decades. Amongst the advantages of the CHG one can highlight the anteroposterior repositioning of the apical bases, the attainment of a normal molar occlusion, modification of the occlusal and palatal planes and reduction of horizontal overlapping.[4,11,19] When the extraoral appliance is incorrectly employed, it causes an extrusive effect on the permanent upper molars, an increase in the anteroposterior facial height and rotation of the mandibular plane in the clockwise direction, making the malocclusion even worse, especially in patients with a dolicofacial pattern.[14]

Only two papers were found in the literature focused on the treatment of Class II, division 1 malocclusion with the Kloehn extraoral cervical appliance and lower utility arch.[4,22]

According to Ricketts et al,[18] the CHG can stabilize the mandibular plane and facial axis of the brachyfacials, rotating the mandible in the anticlockwise direction, and thus decreasing the anteroposterior facial height and the mandibular plane angle. The combined headgear (HG) should be used in Class II, division 1 dolicofacial patients, so that the mandible does not rotate in a clockwise direction and does not increase the lower facial height.

Based on the above aspects, the present study proposed to make a cephalometric evaluation of the maxilomandibular changes occurring when applying Bioprogressive treatment using the Kloehn CHG to the upper arch, together with the use of a lower utility arch, for the correction of Class II, division 1 malocclusion in dolicofacial patients, mainly evaluating the vertical control.

MATERIAL AND METHODS

This study was carried out to obtain the title of Master in Orthodontics, and was only started after approval by the Ethics Commission for Research with Human Beings of FOP-UNICAMP, Brazil.

Sample

The sample consisted of 52 lateral cephalometric radiographs obtained at two moments in time, before (T1) and at the end (T2) of an orthodontic treatment with 26 patients, 13 girls and 13 boys, with Class II, division 1 malocclusion and dolicofacial skeletal patterns, with a mean age of 114 months and mean treatment time of 56 months. The patients were selected according to the following inclusion criteria:

» Brazilian white patients, submitted to orthodontic treatment at the Orthodontic Clinic of the Specialization Course offered by the Ribeirão Preto Dental Association (AORP), Brazil;
» Patients with absence of syndromes and good oral health;
» Class II molar and canine relationship;
» Overjet > 2.5mm;
» ANB angle > 4°;
» FMA angle >25°;
» SNGoGn > 35°.

Description of the orthodontic treatment according to Ricketts Bioprogressive Philosophy

The treatment of Class II, division 1 malocclusion was performed without any tooth extraction (except for the third molars, when necessary), and according to the Bioprogressive Philosophy, at the Specialization in Orthodontics and Facial Orthopedics Clinic of the Ribeirão Preto Dental Association – AORP. To correct the anteroposterior relationship of the apical bases, the Kloehn type extraoral cervical traction appliance (CHG) was used, which is characterized by an internal arch fitted into triple tubes, welded to the braces on the maxillary first molars, and an external rigid arch, inclined 20º upwards with respect to the internal arch (which is parallel to the occlusal plane), and a cervical band with elastics, pre-adjusted to generate a total force of 450g, adapted to the external arch. The patients were instructed to use the CHG for a period of 12h/day, including while asleep, with the objective of correcting the molar relationship. This period lasted approximately 1 year, and after obtaining normal molar occlusion, the CHG was gradually removed, decreasing the number of hours of use until complete withdrawal.

Concomitant with the use of the CHG on the maxilla, the lower utility arch (LUA), made of 0.016x0.016-in Elgiloy Blue wire, was adapted to the lower arch. The molar sector of the LUA was fitted into the cervical tubes of the double tubes welded onto the lower first molar bands, and the incisor sector of the LUA onto the brackets of the four mandibular incisors. Activations were performed both for verticalizing and anchoring the mandibular molars in the cortical bone, with the objective of limiting their eruption (caudal angle of 30-45º, caudal deviation of 10-20º, buccal root torque of 30-45º and expansion of 10 mm in the molar sector), as well as intruding or uprighting the mandibular incisors according to the requirements of each case (in the incisor sector, a buccal root torque of 5-10º was incorporated). After uprighting of the mandibular molars, brackets were placed on the premolars, and a stabilizer segmented arch made of 0.016x0.016-in Elgiloy Blue wire was adapted on each side of the occlusal tube of the double tubes welded to the bands of the mandibular first molars, which extended up to the first mandibular premolars, with the object of avoiding excessive inclination of the mandibular molars in the distal direction, while the mandibular incisors were being intruded. The orthodontic treatment proceeded using the Bioprogressive Therapy until the cases were finished, with a harmonious profile and characteristics of normal occlusion.

Cephalometric method

The anatomic structures and cephalometric points were marked, the planes and lines drawn, and the following angular (Fig 1) and linear (Fig 2) variables measured:

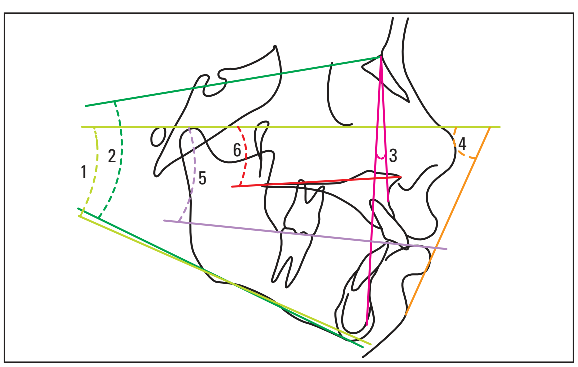

FIGURE 1 - Angular variables: 1) FMA; 2) SNGoGn; 3) ANB; 4) Z Angle; 5) OPA; 6) PPA.

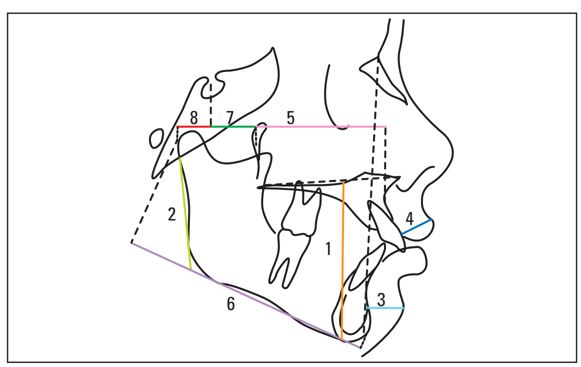

FIGURE 2 - Linear variables. 1) AFH; 2) PFH; 3) TC; 4) UL; 5) Max L; 6) Mand L; 7) S-FPm; 8) Fg-S.

Statistical analysis

The statistical analysis consisted of a univariate analysis to determine the distributions and verify the outliers and normality tests (Shapiro-Wilkens).

The "t" test was used for the comparisons of means in normal distributions. When the "t" test was performed, the equality of variances was tested using the Levene test. When the variances of the groups were shown to be different, the Satterthwaite adjustment was used.

For normal distributions, when data dependence occurred (comparison of means from one and the same individual), the paired "t" test was used. For non normal distributions the Kruskal-Wallis comparison of means test was used, and for the comparison of paired data with non normal distribution, the signed-rank test was used.

Method of Error

The same researcher traced each cephalometric radiograph twice, in an interval of 30 days, and obtained two values for each cephalometric variable. The arithmetic mean of these values was used in the statistical analysis. The Dahlberg index was used to interpret the casual error.[10]

TABLE 1 - Characteristic of the patients with respect to age at the beginning and during orthodontic treatment.

	Total (n=26)	Girls (n=13)	Boys (n=13)	p*
Age (months)				
Mean	114.0	127.5	120.0	0.8170
Q1	105.0	105.0	105.0	
Q3	131.0	130.0	131.0	
Min - Max	96 - 201	100 -155	96 - 120	
Duration of Treatment (months)				
Mean	56.0	56.0	57.0	0.7192
Q1	45.0	45.0	48.0	
Q3	67.0	68.0	59.0	
Min - Max	27 - 169	27 - 169	36 -103	

*Value of P for comparison of means - Kruskal-Wallis test ($P < 0.05$ significant).

RESULTS

Sample

Comparison between sexes

No statistically significant difference was observed between the sexes with respect to the alterations that occurred, when the two moments in time were compared (Table 2) for the whole sample.

Comparison of the cephalometric variables

Since no statistical differences were found between the sexes with respect to the initial ages and alterations occurring with the treatment, the sexes were placed together in the same group (Table 3).

TABLE 2 - Comparison of the paired differences between sexes.

	Girls (n=13)			Boys (n=13)			
	Pair. diff.	SD	SE	Pair. diff.	SD	SE	p*
FMA	-1.88	3.04	0.84	-1.35	1.78	0.49	0.5877
SN.GoGn	-1.34	2.74	0.76	-2.19	3.61	1.00	0.5081
ANB	-2.21	1.30	0.21	-3.00	1.36	0.38	0.0810
Fg-S	1.12	1.30	0.36	0.61	1.66	0.46	0.3955
S-FPm	0.57	1.10	0.31	0.58	1.01	0.28	0.9854
Maxillary length	2.18	1.70	0.47	1.53	1.62	0.44	0.3348
Mandibular length	9.08	3.33	0.92	9.81	4.79	1.33	0.6547
PFH	6.60	3.69	1.02	9.78	4.39	1.22	0.0582
AFH	6.39	2.98	0.82	8.05	3.09	0.86	0.1754
FHI	0.008	0.04	0.01	0.008	0.021	0.006	0.9458
Occlusal Pl. Angle	-0.77	3.03	0.84	0.61	3.24	0.90	0.2713
Palatal Pl. Angle	0.23	2.88	0.80	-1.40	2.06	0.57	0.1089
TC	1.61	2.32	0.64	2.06	1.59	0.44	0.5629
UL	1.33	3.38	0.94	1.84	2.34	0.65	0.6580
Z Angle	9.69	5.78	1.60	6.96	4.23	1.18	0.1826

*P Value for the paired Student-t test ($P < 0.05$ – significant).

TABLE 3 - Comparison of the paired differences of all variables.

	Beginning		End		Diff.			p*
	Mean	SD	Mean	SD	Paired	SD	SE	
FMA	28.98	4.01	27.36	4.11	-1.62	2.96	0.48	**0.0026***
SN.GoGn	39.21	3.79	37.44	4.29	-1.77	3.18	0.62	**0.0088***
ANB	6.11	1.63	3.50	1.77	-2.61	1.15	0.22	**< 0.0001****
Fg-S	15.58	2.78	16.45	3.23	0.87	1.49	0.29	**0.0064***
S-FPm	18.59	1.93	19.17	2.33	0.57	1.03	0.20	**0.0089***
Maxillary Length	51.10	3.30	52.96	3.57	1.86	1.67	0.33	**< 0.0001****
Mandibular Length	103.05	4.54	112.49	5.16	9.44	4.06	0.80	**< 0.0001****
PFH	38.59	1.48	46.78	4.21	8.19	4.30	0.84	**< 0.0001****
AFH	62.90	3.48	70.12	4.5	7.22	3.09	0.61	**< 0.0001****
FHI	0.65	0.04	0.66	0.05	0.008	0.29	0.006	0.1830
Occlusal Pl. Angle	7.48	4.26	7.40	3.03	-0.08	3.15	0.62	0.9020
Palatal Pl. Angle	3.27	3.57	2.69	3.60	-0.59	2.59	0.50	0.2592
TC	14.03	1.63	15.87	2.09	1.84	1.96	0.38	**< 0.0001****
UL	11.53	2.91	13.12	1.96	1.59	2.86	0.56	**0.0090***
Z Angle	61.98	6.36	70.31	6.49	8.33	5.16	1.01	**< 0.0001****

*P Value for the paired Student-t test (*P < 0.05 and **P < 0.0001– significant).

DISCUSSION

Vertical control of the face during the use of orthodontic mechanics has been shown to be of utmost importance in obtaining functional esthetic balance, essential for the final result of a treatment aimed at facial harmony and post-treatment stability.[6,8]

Various types of appliance have been studied and developed for the correction of Class II, one of which is the cervical headgear.[12] There is a great deal of controversy in the literature with respect to the changes occurring with the use of the cervical headgear. However, the considerations most reported are correlated to the extrusive effect on the permanent maxillary molars, downward inclination of the anterior part of the palatal plane and the increase in inclination of the mandibular plane, aggravating the vertical problem even more.[14] According to Ricketts,[17] cervical traction produces favorable changes for patients with Class II, division 1, such as: retraction of the maxillary complex, decrease in maxillary convexity and rotation of the palatal plane in the clockwise direction. Some studies have shown that maxillary molar extrusion could be minimal when the CHG is used with the external arch inclined 20º above the internal arch.[4,11,22]

The sole purpose of this study was to investigate the effectiveness of orthodontic treatment and vertical control in a sample selected from the orthodontic documentation file belonging to the Specialization Course in Dentistry and Facial Orthopedics of the Ribeirão Preto Dental Association - AORP, Brazil.

The data assessed were submitted to a statistical analysis by applying the paired Student-t test. It was observed that no statistically significant differences occurred between the sexes for the initial ages, treatment time or for the alterations that occurred with the orthodontic treatment (Tables 1 and 2). Thus both sexes were assessed in a single group, only studying the alterations occurring between the two moments in time (initial and final).

Assessment of the craniofacial growth pattern is very important, particularly during the growth phase, since selecting the direction of the application of forces depends directly on this evaluation, and can be low, straight or high. According to some authors,[6,15] orthodontic treatment should not alter the measurements related to vertical control or cause significant mandibular rotation in a clockwise direction, especially in dolicofacial patients. These patients normally have an increased lower facial height, with the mandible positioned more backwards and downwards. If the orthodontic treatment causes clockwise mandibular rotation, there will be an increase in the height, worsening the facial profile of these patients even more.

In the present study carried out with dolicofacial patients submitted to orthodontic treatment with a CHG (with activations of the external arch) and a lower utility arch, there was a statistically significant decrease in the variables that represent the facial pattern and vertical control: angles FMA -1.62±2.96º and SNGoGn -1.77±3.18º (Table 3). This result showed that the mandibular plane was stabilized during orthodontic treatment, allowing for the reasoning that the clinically observed alterations were not expressive, since the alteration remained at approximately 1.6º and the standard deviation of around 3º. This result corroborated the results of Decosse and Horn,[6] who reported that the values of these angles should be maintained with the use of orthodontic mechanics for vertical control to occur. Other results found in the literature showed the stability of the variables referring to the facial pattern with treatment.[3,4,11,12] Ricketts et al[18] reported that the use of the CHG together with the lower utility arch could cause anti-clockwise rotation of the mandible in brachyfacial patients, which they[18] denominated as the Inverse Reaction. According to these authors,[18] when the upper molar (Fig 3A) is extruded and distalized in an intermittent way, its inclined planes act to upright and distalize the lower first molar. This occurrence is accentuated by the distal degree of the utility arch (Fig 3B) and labial torque of the root of the lower incisor (Fig 3D). The vertical action of the masseter and pterygoid muscles (Fig 3C) functions in the stabilization of the eruption of the lower molar (Fig 3F) and also limits extrusion of the upper molar. The torque of the labial root on the lower utility arch (Fig 3E) also allowed for the lower incisor to avoid the cortical one while being intruded. The present study assessed dolicofacial patients and showed that the treatment can also result in a tendency for anti-clockwise rotation of the mandible (tendency, since it was considered that the change that occurred — about 1.6º — was not clinically expressive). This alteration occurred due to the intermittent use (12h/day, including while asleep) of the CHG, with activation of the external arch and use of a lower utility arch, which promotes anchorage of the lower molars. A 20º activation of the external arch above the internal arch made the resulting force pass through the center of resistance of the upper molar, promoting an action that controlled the extrusive effect on the upper molars. This result corroborated the findings of Cook et al[4] and Ulger et al,[22] who carried out a study using the CHG with activation of the external arch and use of a lower utility arch, and reported that the mandibular plane remained unaltered even in dolicofacial patients.[4] Kirjavainen

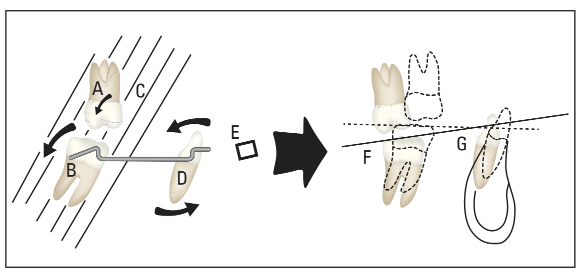

FIGURE 3 - Inverse Reaction – Combined action of the the CHG and LUA. A) upper first molar, B) LUA distal degree, C) vertical action of the masseter and pterygoid muscles, D) buccal root torque of the lower incisors, E) wire activation to generate buccal root torque on the lower incisors, F) limited eruption of the lower first molars, G) lingual movement of the lower incisors and change the functional occlusion plane. Source: Ricketts et al.[18]

et al[11] reported the occurrence of minimal extrusion of the upper molars in patients who used the CHG with activation of the external arch.

The maxilla protruded slightly with respect to the cranial base at the start of the dental treatment (Table 3), and at the end of the treatment a mild, but statistically significant, forward displacement could be observed. The variable S-FPm showed an increase of 0.57±1.03 mm (Table 3), suggesting that the use of the CHG restricted forward displacement of the maxilla, the mean displacement being 0.57 mm in a period of 4.6 years. Its anteroposterior dimension (FPm-point A) showed a statistically significant increase of 1.86±1.67 mm. Siqueira[20] assessed Brazilian patients with normal occlusion and showed that the length of the maxilla increased approximately 3.34 mm from 9 to 10 years of age, and thus it is reasonable to consider that the anteroposterior dimension of the maxilla was restricted by the use of the CHG, since it only increased 2 mm in a period of 4.6 years.

The mandible protruded in relation to the cranial base at the start of treatment (Table 3), but by the end of treatment, the variable Fg-S showed a value of 16.45±3.23 mm, indicating an approximation to the standard value determined by Wylie,[25] suggesting an improvement in the anteroposterior mandibular position in relation to the cranial base. The anteroposterior dimension increased significantly during the assessment period, showing an expressive increase in length of 9.44±4.06 mm (Table 3). According to Ricketts et al,[18] this increase could have occurred due to mandibular unlocking or to decompression of the condyle in the glenoid cavity, freeing the mandible for normal growth.

According to Antonini et al,[1] Broadbent et al[2] and Ricketts,[16] the relationship of the maxillary complex with the cranial base remains relatively constant during growth in patients with predominantly vertical growth, and thus orthodontic and/or orthopedic intervention is necessary for the correction of anteroposterior Class II, division 1 malocclusion. The anteroposterior discrepancy was shown to be corrected by means of a highly significant ($P < 0.0001$) alteration in the ANB angle (Table 3). A reduction of 2.61±1.15° occurred, improving the relationship between the apical bases, confirming the results of other authors.[3,4,11,22,23] The reduction in ANB was due mainly to the expressive growth of the mandible and to the possible skeletal alterations occurring in the maxilla.

The facial heights increased significantly, PFH 8.19±4.30 mm ($P<0.0001$) and AFH 7.22±3.09 mm ($P<0.0001$), whereas the FHI (Table 3) showed no statistically significant alteration ($P=0.1830$), occurring a very slight increase in its value, but remaining within the values considered normal by Horn (0.65 to 0.75),[9] the final value obtained being 0.66±0.05. These findings suggest the effectiveness of the orthodontic treatment during the mechanics used, harmonizing the facial heights, since the posterior facial height increased slightly more than the anterior one and the Inverse Reaction.[18]

The alterations occurring in the occlusal and palatal planes were not statistically significant. The occlusal plane angle expresses the dental-skeletal relationship of the occlusal plane with the Frankfurt plane, as determined by the muscular balance. According to some authors,[5,8,24] its value should be maintained or discreetly reduced in order to avoid a relapse. In the present study the occlusal plane angle showed a statistically non-significant reduction of 0.08±3.15° and $P=0.9020$ (Table 3), corroborating with other studies found in the literature.[5,6,24] The palatal plane angle showed a statistically non-significant reduction of 0.59±2.59° and $P=0.2592$ (Table 3). The results observed suggested that the palatal plane had a tendency to rotate in a clockwise direction, confirming the results of other studies.[4,11,18,23]

According to Tamburus et al,[21] the tegumental profile represents the final determinant of the dental positions, since there is no point in orthodontic planning and treatment other than achieving the basic objectives of obtaining good occlusion, if the facial esthetics remain compromised. The alterations occurring to the profile were statistically significant (Table 3). The cephalometric variables TC and UL showed mean values increased by values of 1.84±1.96 mm and 1.59±2.86 mm, respectively, maintaining the proportionality between them (TC≥UL) from start to finish of the treatment.

The Z angle relates the tegumental profile of the patient with the horizontal and vertical senses.[8] At the start of the orthodontic treatment (Table 3), the patients showed a decreased mean value of the Z angle, confirming the convex profile, and one of the objectives of the orthodontic treatment was centered on increasing this angle, thus making the profiles of the patients more harmonious. The results of the present study showed a significant increase in the Z angle (+8.33±5.16° and P<0.001), due mainly to the expressive growth of the mandible, with a final mean of 70.31±6.49°, a value close to the normal values found in the studies of Leichsenring et al[13] and Siqueira[20] for patients with harmonious profiles.

CONCLUSIONS

According to the methodology used and the results obtained in the treatment of Class II, division 1 malocclusions with dolicofacial patients, it was concluded that:

As verified by the significant reduction in the ANB angle, the apical bases of the Class II, division 1 malocclusion were corrected by the use of a Kloehn-type CHG, due mainly to an expressive growth in mandibular length and restriction or redirection of maxillary growth, thus significantly improving the profile. The horizontal planes and facial heights were controlled, as verified by the changes that occurred in the FMA and SNGoGn angles, occlusal plane angle, palatal plane angle and FHI, showing that the orthodontic treatment was effective in the vertical control.

FINAL CONSIDERATIONS

The present study was a retrospective assessment carried out to obtain the title of Master in Orthodontics at FOP/UNICAMP, Brazil.

The idea of carrying out this study came from various years of clinical experience with good results by applying the methodology of Dr. Clóvis Roberto Teixeira and Dr. Weber Luiz Tamburús.

Since only two papers were found in the international literature reporting on the treatment of Class II, division 1 malocclusion with a CHG and lower utility arch, more research is needed in order to confirm and explain all the modifications that occurred.

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