An evaluation of serial extraction among Navajo Indian children

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Within the borders of the United States, there are more than 100,000 Indian children living in rural areas where no orthodontists are available to provide orthodontic services. Of the varied malocclusion problems, many are the result of dental crowding. The crowding problem appears to be accentuated in this ethnic group by large mesiodistal crown diameter. In a survey of tooth size that I carried out on Navajo students, it was found that, on the average, the individual Navajo tooth is 0.37 mm. larger than the average Caucasian tooth. The Navajo lateral incisor is the tooth which varies to the greatest extent. This tendency toward large teeth has also been demonstrated in the Aleut dentition.[14]

The present study was designed to evaluate serial extraction as an adjunct to interceptive orthodontic treatment and particularly to ascertain whether it may be applied advantageously in situations where comprehensive orthodontic services are not available. For the purposes of this article, serial extraction is defined as the predetermined sequential removal of deciduous teeth and four premolars, one in each quadrant, to allow sufficient space for alignment of permanent incisors and subsequent favorable eruption and interdigitation of the remaining permanent canines and premolars.

Methods and procedures

In a screening examination performed on 816 Navajo children residing on the Navajo Reservation, 279 children who had clinical symptoms of dental crowding were selected for appraisal. Orthodontic records were taken on all children selected. These records consisted of a patient history, full-mouth periapical roentgenograms, left and right oblique cephalometric roentgenograms,

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two facial photographs (a lateral and a front view), and four intraoral color transparencies. In preparing the records for analysis, tracings were made from the lateral and the right oblique cephalometric roentgenograms. A mixed-dentition analysis was made in each case as an aid in determining alveolar bone discrepancy.

A group of six practicing orthodontists examined all records, and each orthodontist made recommendations regarding treatment procedures. As comprehensive orthodontic treatment was not to be carried out, recommendations for treatment were based on simple preventive and corrective procedures directed toward space maintenance or tooth movements for the correction of single-tooth cross-bites and rotations. Serial extraction was included as part of the treatment, either in conjunction with a simple appliance or with no other treatment, whatever the orthodontist deemed best for the patient and feasible for application by a general dentist.

The preliminary evaluations and treatment recommendations divided the 279 cases into three main categories:

1. Cases in which full serial extraction, including four premolars, would be beneficial—81 children. In some borderline cases of this group, the final decision regarding extraction was to be delayed until growth factors further manifested themselves.
2. Cases in which certain deciduous and permanent teeth other than four premolars were recommended for extraction—64 children. In a large percentage of this group, the teeth to be ertracted were maxillary first premolars only.
3. Cases in which no extractions of permanent teeth were recommended—134 children.

In the ensuing months the general dentists in the rural areas where the patients lived were informed of the treatment recommendations for the children involved, and the first-phase procedures were implemented. As dental plaque control was recognized as a special problem, at the outset each child attended a class in oral hygiene instruction. Proper toothbrushing, with emphasis on gingival stimulation, was strongly advocated. Brushes were supplied and follow-up examinations were made at 6-month intervals.

Treatment recommendations regarding serial extraction followed the generally accepted procedures.[2, 3, 7] Often deciduous canines were mesially disked where permanent lateral incisors were being displaced. If a deciduous canine had been lost on one side only, the deciduous canine on the opposite side was usually removed to help develop symmetry and avoid midline deviations. Extractions of the deciduous first molars were delayed until the roots of the first premolars were half developed. The first premolars were removed upon eruption. In the mandibular arch in cases in which x-ray examination revealed that the eruption level of the permanent canine and the first premolar was about the same, the first deciduous molar was removed about 6 months before the deciduous canine. This usually caused the first premolar to erupt earlier for more opportune extraction.

In Class II molar relationships, extractions in the mandible were avoided.

Table I. A comparison of means of six lateral skeletal cephalometric values in Navajo children, Navajo adults (after Cole), and Caucasian adults (after Downs)

Group	*Mean age (years and months)*	*Facial angle (degrees)*	*Angle of convexity (degrees)*	*A-B to facial plane (degrees)*	*Mandibular plane (degrees)*	*Y axis (degrees)*	*Body length (mm.)*
Extraction	8-9	86.45	8.75	−5.75	27.84	61.26	70.90
Control	8-9	87.39	8.55	−5.47	26.04	60.21	70.43
Extraction	12-1	86.40	6.31	−5.27	27.93	62.15	77.91
Control	12-1	86.93	7.27	−4.60	26.92	61.52	77.38
Navajo (after Cole)	Adult	87.7	3.40	−4.30	26.20	61.9	—
Caucasian (after Downs)	Adult	87.8	0.00	−4.60	21.90	59.4	—

In some mild Class II situations, however, the lower second deciduous molars were removed and the second premolars were enucleated. In this procedure, the surgical technique avoided destruction of alveolar bone. It was theorized that this method would relieve the crowding and preclude the trapping of the second premolar, but yet not be the cause of excessive uprighting of the lower incisors.

At 6-month intervals, all children for whom original records had been taken were clinically evaluated by the investigator. Lateral and oblique cephalometric roentgenograms were taken for all children on each of these visits. Follow-up treatment recommendations were also made for each child.

The duration of observation and treatment was 40 months. At the end of this time, complete orthodontic records were again taken and the final records, as well as the initial records and all intermediate records, were again reviewed and evaluated by the same group of orthodontists.

Results

Comparative cephalometric studies of the serial-extraction and control groups are shown in Tables I and II. Each group used in the analysis consists of forty children selected on the basis of quality and completeness of records. Within the samples, sexes and age groupings are equally matched. The mean age of both groups was 8 years 9 months when initial records were taken, 9 years 11 months when permanent teeth were extracted, and 12 years 1 month when final records were taken.

Downs' cephalometric analysis has been used. Comparative measurements are shown for initial and final records. Cephalometric readings are also shown for the adult Navajo after Cole and for the adult Caucasian after Downs for comparison.

Skeletal pattern

In Table I the skeletal patterns are represented. None of these measurements reveal any statistically significant differences in the child groups before or after

Table II. A comparison of means of five lateral dental cephalometric values in Navajo children, Navajo adults (after Cole), and Caucasian adults (after Downs)

Group	*Mean age (years and months)*	*Occlusal plane (degrees)*	*Interincisal angle (degrees)*	*Lower incisor to occlusal plane (degrees)*	*Lower incisor to mandibular plane (degrees)*	*Upper incisor to A-Po (mm.)*
Extraction	8-9	13.06	125.53	22.41	6.69	5.80
Control	8-9	11.81	125.81	20.48	7.45	5.29
Extraction	12-1	13.45	132.01*	14.83*	0.93*	6.48*
Control	12-1	12.30	122.17	21.21	7.21	8.45
Navajo (Cole)	Adult	11.2	120.9	23.0	7.4	9.2
Caucasian (Downs)	Adult	9.3	135.4	14.5	1.4	2.7

*Treatment effect = 0.01 level.

treatment. However, in final records, when the mean age is 12 years 1 month and the faces more nearly approach the adult profile, the tendency for the extraction group to exhibit less convexity is in evidence. In the extraction group the angle of convexity decreased from 8.75 degrees to 6.31 degrees, for a reduction of 2.44 degrees. In the control group it decreased from 8.55 degrees to 7.27 degrees, for a reduction of 1.28 degrees. The difference between the reductions in each group which may be attributed to serial extraction is 1.16 degrees. This may be considered a tendency but, as mentioned, it did not prove statistically significant.

In regard to the adult groups, Table I reveals an angle of convexity of 3.4 degrees for the Navajo and 0.0 degrees for the Caucasian, indicating greater convexity among the Navajo. The mandibular plane angle was 26.2 degrees for the Navajo adults and 21.9 degrees for the Caucasians, showing a steeper mandibular plane in the average Navajo.

In addition to the usual measurements in the Downs analysis, measurements of the body of the mandible are listed in the column to the far right in Table I. The body length was determined by the linear distance between a geometric gonion and a geometric gnathion (Fig. 1). The usefulness of this measurement is in obtaining an assessment of growth of the body of the mandible as a specific entity to determine the effect of premolar extraction during the growth period. The initial records show body length at a mean of 70.90 mm. in the extraction group and 70.43 mm. for the control group. Final records indicate 77.91 mm. for the extraction group and 77.38 mm. for the control group. Growth during the 40 months was 7.01 mm. in the extraction group, and in the control group it was 6.95 mm. The results obtained, therefore, support the premise that serial extraction does not cause retardation in growth of the body of the mandible.

Dental pattern

Recorded in Table II are the lateral cephalometric measurements relative to the dental pattern. Analysis of the measurements reveals no significant differences between the extraction and control groups at the beginning of the

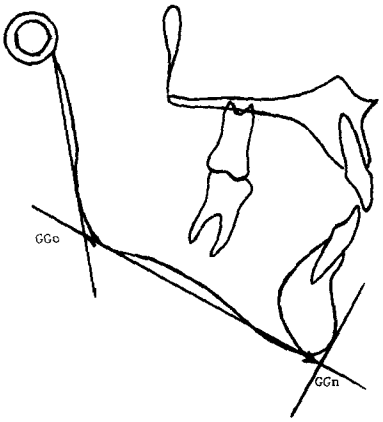

Fig. 1. Lateral cephalometric tracing showing method used in determining length of body of mandible, geometric gonion **(GGo)** to geometric gnathion **(GGn)**. Point GGo is established by the intersection of the mandibular plane and a line tangent to the posterior border of the ramus. Point GGn is established by the intersection of the mandibular plane and a line perpendicular to it and tangent to the bony chin.

study. Following the 40-month study period, however, there were significant differences in all dental relationships except the occlusal plane. The occlusal plane angle in the extraction group increased from 13.06 degrees to 13.45 degrees, a gain of 0.39 degree. It increased from 11.81 degrees to 12.30 degrees in the control group, for a gain of 0.49 degree. Change attributed to serial extraction was only 0.10 degree. The interincisal angle of the extraction group increased from 125.53 degrees to 132.01 degrees, for a gain of 6.48 degrees. In the control group, it decreased from 125.81 degrees to 122.17 degrees, for a reduction of 3.64 degrees. The net difference in the two groups attributable to serial extraction is 10.12 degrees.

The angulation of the lower incisor to the occlusal plane in the extraction group decreased from 22.41 degrees to 14.83 degrees, for a reduction of 7.58 degrees. In the control group this angulation increased from 20.48 degrees to 21.21 degrees, for a gain of 0.73 degree. The change toward more uprightness attributable to serial extraction was 8.31 degrees. The angulation of the lower incisor to the mandibular plane in the extraction group decreased from 6.69 degrees to 0.93 degree, for a reduction of 5.76 degrees. In the control group this angle decreased from 7.45 degrees to 7.21 degrees, for a reduction of 0.24 degree. The net reduction in the angle attributable to serial extraction was 5.52 degrees. The upper incisor to the A-Po line increased from 5.80 mm. to 6.48 mm., for a gain of 0.68 mm. in the extraction group. The distance in the control group increased from 5.29 mm. to 8.45 mm., for a gain of 3.16 mm. The net difference attributable to serial extraction is 2.48 mm. In the adult dental pattern, we note that, in line with the differences in the skeletal pattern, the posture of the incisors in the adult Navajo indicates greater procumbency and labial positioning. It is interesting to note that the final extraction group measurements closely approximate those of the adult Caucasian, and the final control group measurements closely approximate those of the adult Navajo, as would be expected.

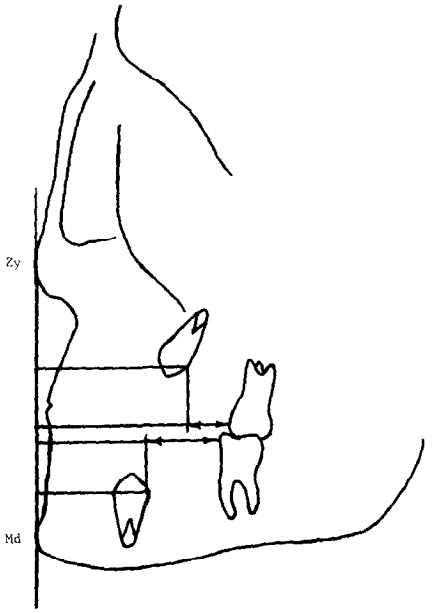

Fig. 2. Oblique cephalometric tracing showing method of determining distances between the permanent canines and first molars. Determinations were made by subtracting the distance of the distal contact point of the canine to the reference line **Zy-Md** from the distance of the mesial contact point of the molar to the reference line. The reference line **Zy-Md** is established by the heights of contour of the most anterior protuberances of the zygomatic and mandibular bones as viewed from the oblique.

Table III. Distances between permanent canines and first molars

	Dental arch			
	Mandibular		*Maxillary*	
	Extraction (mm.)	*Control (mm.)*	*Extraction (mm.)*	*Control (mm.)*
Initial records	16.29	17.57	7.00	12.71
Final records	9.29*	14.79	9.65*	15.04
Difference	2.42	2.78	12.07	2.33

*Treatment effect = 0.01 level.

Canine to first molar spacing

In order to evaluate the positional changes of teeth in the buccal segments accurately, oblique cephalometric roentgenograms were taken at 45 degrees to the sagittal plane. In this way the x-rays passed through one side of each dental arch for each exposure. This method has the advantage of avoiding superimposition of the teeth studied and allows the central ray to pass nearly perpendicular to the line of occlusion in each buccal segment. In Table III are recorded distances between canines and first permanent molars in the initial and final records. These linear measurements were made along lines perpendicular to the zygomaticomandibular reference line established on the oblique cephalometric x-ray (Fig. 2).

Table IV. Inclination of first molars to line of occlusion

	Dental arch			
	Mandibular		*Maxillary*	
	Extraction (degrees)	*Control (degrees)*	*Extraction (degrees)*	*Control (degrees)*
Initial records	57.09	59.39	79.42	78.67
Final records	55.52*	59.18	75.57*	78.09
Difference	1.57	.21	3.85	0.58

*Treatment effect = 0.01 level.

Initially there were no significant group differences in the canine to first molar spacing. However, the final records demonstrate significant differences. In the mandibular arch the canine to first molar spacing of the extraction group decreased from 16.29 mm. for a change of 7.00 mm. In the control group the distance decreased from 17.57 mm. to 14.79 mm., for a change of 2.78 mm. The difference in the two net reductions attributable to serial extraction was 4.22 mm. Of this amount of closure, it was determined that 3.18 mm. (75 per cent) was a result of canine movement and 1.04 mm. (24.7 per cent) was a result of molar movement. This determination was made by measuring individual movement of the teeth, through time, relative to the Zy-Md reference line.

In the maxillary arch the canine to first molar distance in the extraction group decreased from 12.07 mm. to 9.65 mm., the net reduction being 2.42 mm. In the control group, however, the distance increased from 12.71 mm. to 15.04 mm., for a gain of 2.33 mm. This gain resulted primarily from the forward movement of the canine as it erupted toward the line of occlusion. The net difference attributable to serial extraction was 4.75 mm. Of this difference, 3.40 mm. (71.6 per cent) was a result of canine movement and 1.35 mm. (28.4 per cent) was a result of molar movement. Spacing remaining at the extraction sites in the final records was not considered excessive, and anterior tooth relationship as well as buccal interdigitation was generally much better than it would have been if no treatment procedures had been carried out.

In the maxillary arch, 7 per cent of the cases had spacing of 1 mm. or more remaining at the extraction sites. Of this number, only one space out of five was more than 2 mm. in size. Therefore, only 1 per cent of all remaining spaces was larger than 2 mm. The mandibular arch did not fare quite so well. In this arch 43 per cent of the cases had spacing of 1 mm. or more at the extraction sites. Of this number, however, only one out of three spaces was more than 2 mm. in size. Therefore, 14 per cent of all remaining spaces were larger than 2 mm. However, in no case was there any excessive tipping of the teeth or any resulting periodontal problem.

Inclination of first permanent molars

Recorded in Table IV are angles of inclinations of first molars as related to the line of occlusion in the oblique cephalometric roentgenogram (Fig. 3).

During the study period, the inclination of the mandibular molar in the

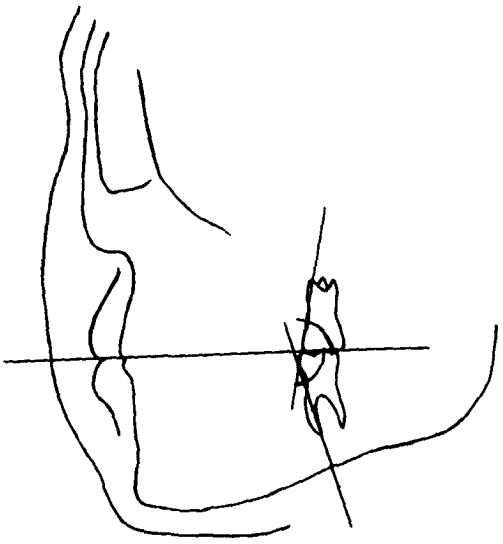

Fig. 3. Oblique cephalometric tracing showing method of determining inclination of the first molar to the line of occlusion. For the establishment of the line of occlusion, the posterior reference point is one-half the cusp height of the first molars and the anterior reference point is the confluence of the upper and lower lip contour. This anterior point was selected because of its stability as compared to any anterior tooth-oriented position during a period when deciduous teeth were being replaced with permanent teeth. The posterior angle is measured.

extraction group changed from 57.09 degrees to 55.52 degrees, for a net decrease in uprightness or increase in mesial tipping of 1.57 degrees. In the control group the change was from 59.39 degrees to 59.18 degrees, for a net decrease of 0.21 degree. The difference in mesial inclination attributable to serial extraction was 1.36 degrees on the average. Although this inclination change is small, it does indicate statistical significance.

The maxillary first molar in the extraction group had an average initial mesial inclination of 79.42 degrees and a final inclination of 75.57 degrees, for an increase in mesial typing of 3.85 degrees. In the control group the angle changed from 78.67 degrees to 78.09 degrees, for an increase in mesial tipping of 0.58 degree. The difference in the inclination resulting from serial extraction was 3.27 degrees. Again, the figures indicate a statistical significance.

Among the children who had undergone serial extraction, there was no excessive overbite in this study. To a large extent, this may be due to original case selection. However, it does appear to support the supposition that the general growth pattern as illustrated in the Navajo does have a resistance to development of deep overbite.

Discussion

In many discussions on the subject of serial extraction, the changes taking place in the dentofacial pattern resulting from the extraction procedure are viewed with apprehension. The feeling is unquestionably justified because of

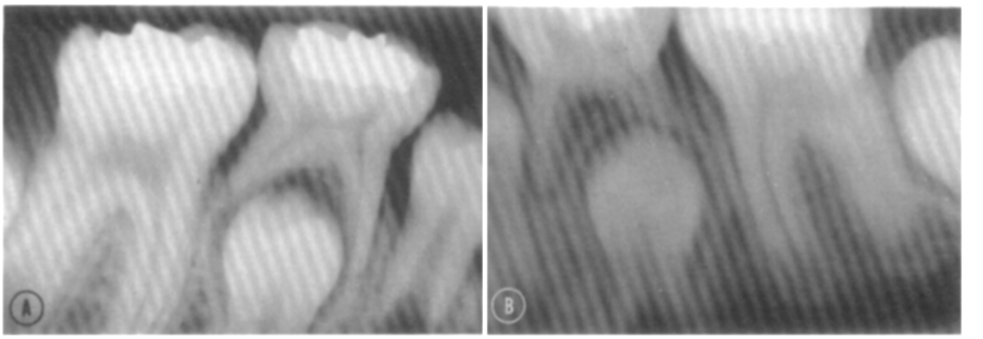

Fig. 4. Periapical roentgenograms before serial extraction. **A,** Right side, where resorption of both roots of second deciduous molar took place. **B,** Left side, where there was resorption of distal root only. Note bone between premolar crown and mesial root of the deciduous molar.

several factors involved. The deep overbite which often accompanies excessively upright or lingually tipped incisors and the lack of esthetic fullness in the lower face profile are chief among these. However, these factors did not enter in as problems in this dentofacial study.

One of the reasons suggested for the favorable result is case selection. The fact that mandibular extractions were not performed in Class II cases and that the tendency for deep overbite is very meager among the ethnic group studied undoubtedly had a great deal to do with the outcome. It is likely that the general growth pattern and facial characteristics of the people have an important bearing. The panel of orthodontists thought that the results of extraction were decidedly for the better, even though many orthodontic needs were left unmet.

Among the various growth factors implicated in developing a satisfactory treatment plan where serial extraction is involved, a few observations are pointed out which appear to be pertinent. It is recognized that second premolars do not always resorb the roots of the second deciduous molars in the same fashion. Among the children studied it was observed that root resorption of the second deciduous molars took place in two ways. The second premolar emerged directly between the deciduous roots, resorbing both roots at about the same rate, or it emerged slightly distally, resorbing only the distal root. Rarely did it resorb the mesial root only in this group.

In situations in which only the distal root was resorbed, the deciduous molar did not become loose, even when the root of the premolar was very far along in its development. This is a condition in which the second deciduous molar is particularly efficient in maintaining spacing. This fact, which was brought to my attention in some extraction cases which exhibited spacing at the extraction site in the final records, points out the need to follow through with serial extraction to include second deciduous molars where it is necessary to lose space.

In one extraction case which emphasized this point, the lower second premolar on the right side resorbed both roots of its deciduous precursor, causing normal exfoliation, while on the left side the second premolar resorbed the distal root only, causing overretention. Good space closure is noted on the side of normal

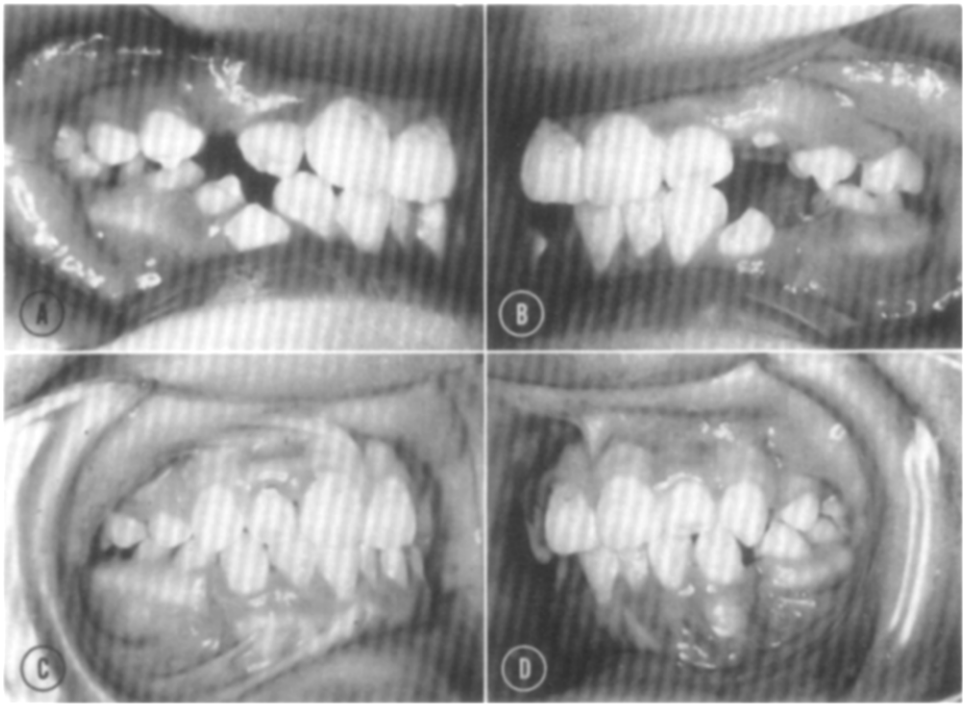

Fig. 5. A and **B**, Conditions before serial extraction was performed. **C** and **D**, Conditions after removal of all four first premolars and eruption of all permanent teeth. No appliance therapy was utilized. Note spacing at extraction site on lower left side **(D)**.

exfoliation, but more than 2 mm. of space remained on the overretained side. This case is illustrated in Figs. 4 and 5.

Another conclusion is that enucleation of premolars in the mandible is sometimes indicated. It was mentioned earlier that enucleations were performed in this study where necessary to prevent trapping of premolars and if space loss was desirable in the mandible to produce a full Class I molar relation. It was noted that, with enucleation, space adjustments can begin at an earlier age and produce a very satisfactory result. It must be remembered, however, that alveolar bone is not to be sacrificed in the surgical procedure. Sectioning of the premolar with the use of high-speed equipment and removal through the deciduous tooth socket is the treatment of choice.

It is concluded that serial extraction, when properly applied, can be useful in preventing severe malocclusion in the population studied.

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