

AMERICAN BOARD OF ORTHODONTICS

Objective grading system for dental casts and panoramic radiographs

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INTRODUCTION

The American Board of Orthodontics is constantly striving to make the phase III clinical examination a fair, accurate, and meaningful experience for candidates. In an effort to enhance the reliability of the examiners and provide the candidates with a tool to assess the adequacy of their finished orthodontic results, the Board has established an Objective Grading System to evaluate the final dental casts and panoramic radiographs. This scoring system has been developed systematically through a series of four field tests over a period of 5 years. The Board is now instituting the model and radiographic portions of the Objective Grading System, which will be officially used to grade these portions of the candidates' clinical case reports beginning in 1999. In an effort to assist the candidates with the selection of their cases, the Board is making this Objective Grading System available to all candidates. The Board encourages candidates to score their own case reports with this scoring system to determine if they meet Board standards.

BACKGROUND

In 1994, the American Board of Orthodontics began investigating methods of making the phase III examination more objective. Because a major emphasis has always been placed on the final occlusion, the first efforts were directed at developing an objective method of evaluating the dental casts and intraoral radiographs.

In the past, several indexes have been used to evaluate the outcome of orthodontic treatment.¹⁻⁴ Generally, these indexes compare pretreatment and posttreatment records to determine the quality of the final result. However, these indexes are not precise, and the validity and reliability of these indexes have not been established. The Occlusal Index⁵ has also been used to deter-

mine treatment quality. However, this method is tedious, and the system is more appropriate for scoring pretreatment rather than posttreatment records.

In 1987, the PAR (Peer Assessment Rating) Index⁶ was developed to assess an occlusion at any stage of development. Over 200 dental casts representing various pretreatment and posttreatment stages of occlusion were used to establish this index. The PAR Index has good reliability and validity, however, this measuring system is not precise enough to discriminate between the minor inadequacies of tooth position that are found in ABO case reports. Therefore, an ABO committee was formed in 1994, to begin field testing precise methods of objectively evaluating posttreatment dental casts and panoramic radiographs.

At the 1995 ABO Phase III examination, 100 cases were evaluated. A series of 15 criteria were measured on each of the final dental casts and panoramic radiographs. The data showed that 85% of the inadequacies in the final results occurred in 7 of the 15 criteria (alignment, marginal ridges, buccolingual inclination, overjet, occlusal relationships, occlusal contacts, root angulation).

Therefore, at the 1996 phase III examination, a second field test was initiated to verify the results of the previous test and to determine if multiple examiners could score the records reliably and consistently. In this field test, 300 sets of final dental casts and panoramic radiographs were evaluated by a subcommittee of four directors. Again, the majority of the inadequacies in the final results occurred in the same seven categories, but the committee had difficulty establishing adequate interexaminer reliability. The subcommittee recommended that a measuring instrument be developed to make the measuring process more reliable.

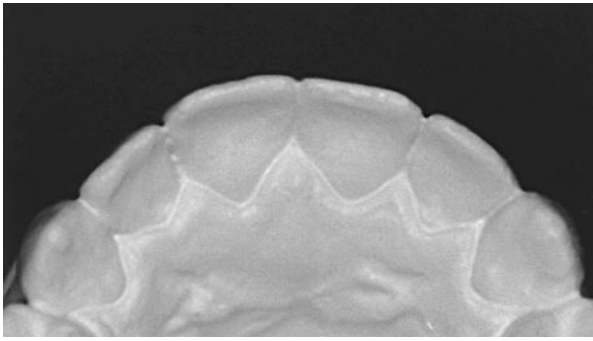


Fig 1

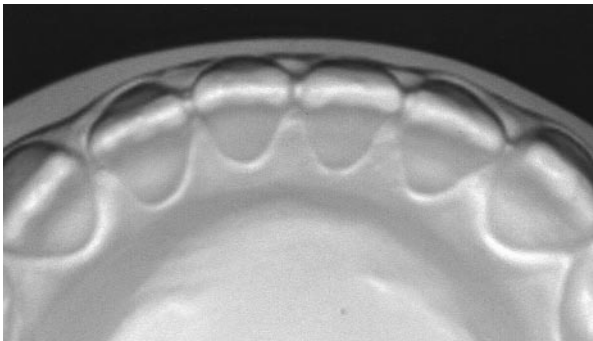


Fig 2

In 1997, a third field test was performed with the modified scoring system and the addition of an instrument to measure the various criteria more accurately. All of the directors participated in this field test, and a total of 832 dental casts and panoramic radiographs were measured. The same seven criteria were evaluated. A calibration session preceded the examination to establish more accurate use of the measuring instrument and improve the reliability of the directors. The results again showed that the overwhelming majority of the inadequacies in the finished results occurred in the aforementioned categories. However, the directors decided to add interproximal contacts to the scoring system to raise the total number of criteria to eight. In addition, modifications were made in the measuring instrument to improve measuring accuracy among directors.

In 1998, the fourth and final field test was initiated. Again all directors participated in the evaluation process. The new and improved measuring instrument was used. An extensive training and calibration session was performed before the actual examination. The major objectives of this final field test were to refine the measuring and calibration process and to gather enough data on general performance to establish the validity or cutoff for passing this portion of the phase

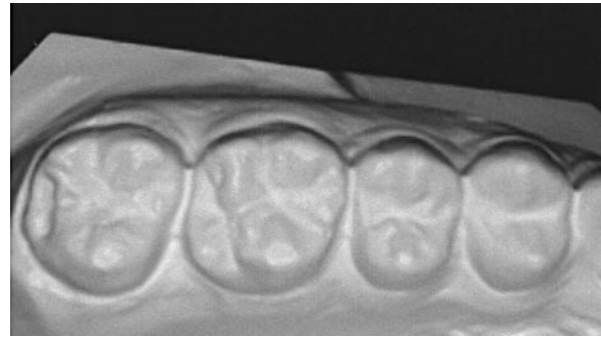


Fig 3

III examination. This field test was extremely successful. Not only did it reaffirm the benefits of using an objective system for grading the dental casts and panoramic radiographs, but it helped to establish standards for successful completion of this portion of the phase III examination.

Based on the collective and cumulative results of these extensive field tests, the Board has decided to officially initiate the use of this Objective Grading System for candidates who will be examined at the February 1999, ABO Phase III examination in St. Louis. In order to assist the candidate in selecting cases that will successfully pass the examination process, the Board is providing the candidate with the same system used by the directors. The Board encourages candidates to score their own dental casts and panoramic radiographs during their preparation for the phase III examination in order to select cases that will successfully pass the ABO Objective Grading System.

CRITERIA AND RATIONALE

The ABO Objective Grading System for scoring dental casts and panoramic radiographs contains eight criteria: alignment, marginal ridges, buccolingual inclination, occlusal relationships, occlusal contacts, overjet, interproximal contacts, and root angulation. The rationale for using these criteria is stated in the following section.

Alignment

Alignment is usually a fundamental objective of any orthodontic treatment plan. Therefore, it seems reasonable that any assessment of the quality of orthodontic results must contain an assessment of tooth alignment. In the anterior region, the incisal edges and lingual surfaces of the maxillary anterior teeth and the incisal edges and labial-incisal surfaces of the mandibular anterior teeth were chosen as the guide to assess anterior alignment. These are not only the functioning areas of these teeth, but they also

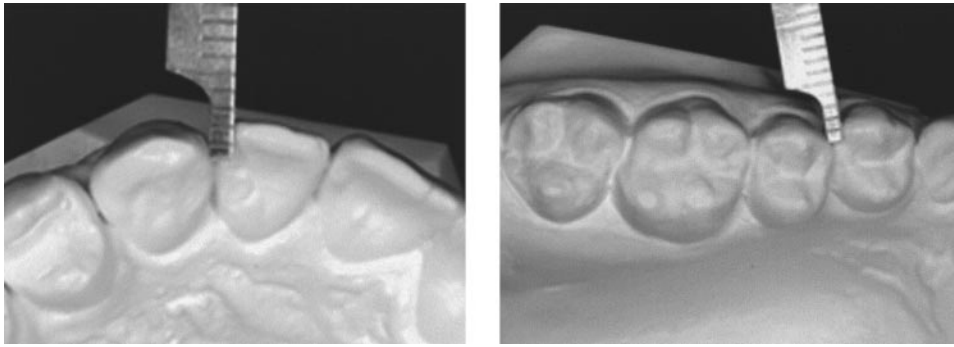


Fig 4

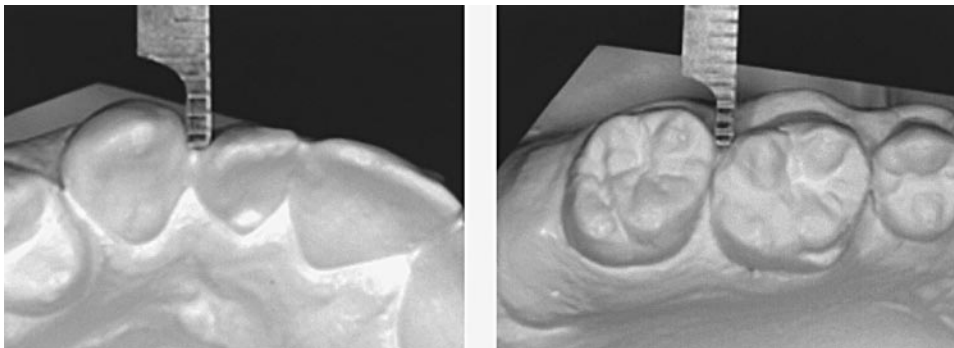


Fig 5

affect esthetics if they are not arranged in proper relationship. In the maxillary posterior region, the mesiodistal central groove of the premolars and molars is used to assess adequacy of alignment. In the mandibular arch, the buccal cusps of the premolars and molars are used to assess proper alignment. These areas were chosen because they represent easily identifiable points on the teeth, and represent the functioning areas of the posterior teeth. The results of the four field tests show that the most commonly malaligned teeth were the maxillary and mandibular lateral incisors and second molars, which accounted for nearly 80% of the mistakes.

Marginal Ridges

Marginal ridges are used to assess proper vertical positioning of the posterior teeth. In patients with no restorations, minimal attrition, and no periodontal bone loss, the marginal ridges of adjacent teeth should be at the same level. If the marginal ridges are at the same relative height, the cemento-enamel junctions will be at the same level. In a periodontally healthy individual, this will result in flat bone level between adjacent teeth. In addition, if marginal ridges are at the same height, it will be easier to establish proper occlusal contacts, because some marginal ridges pro-

vide contact areas for opposing cusps. Based on the four field tests, the most common mistakes in marginal ridge alignment occurred between the maxillary first and second molars. The second most common problem area was between the mandibular first and second molars.

Buccolingual Inclination

The buccolingual inclination is used to assess the buccolingual angulation of the posterior teeth. In order to establish proper occlusion in maximum intercuspation and avoid balancing interferences, there should not be a significant difference between the heights of the buccal and lingual cusps of the maxillary and mandibular molars and premolars. The directors use a special step gauge to assess this relationship. Some latitude is allowed, however, in past field tests significant problems were observed in the buccolingual inclination of the maxillary and mandibular second molars.

Occlusal Relationship

The occlusal relationship is used to assess the relative anteroposterior position of the maxillary and mandibular posterior teeth. In order to achieve accuracy and reliability in measuring this relationship, results

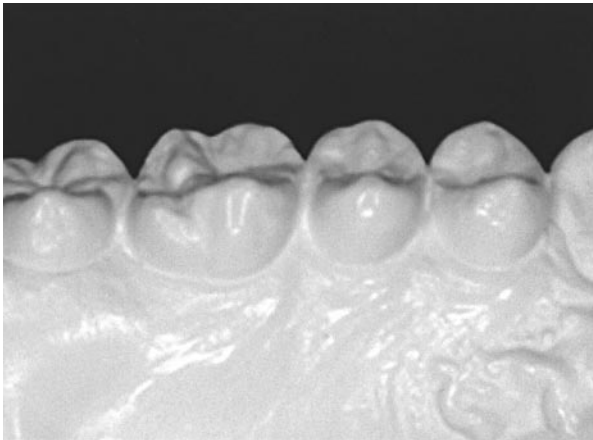


Fig 6

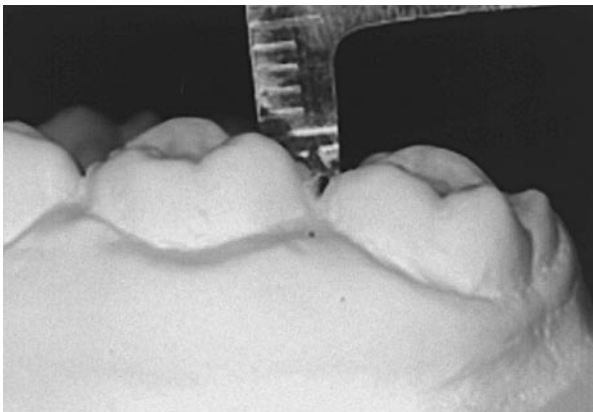


Fig 7

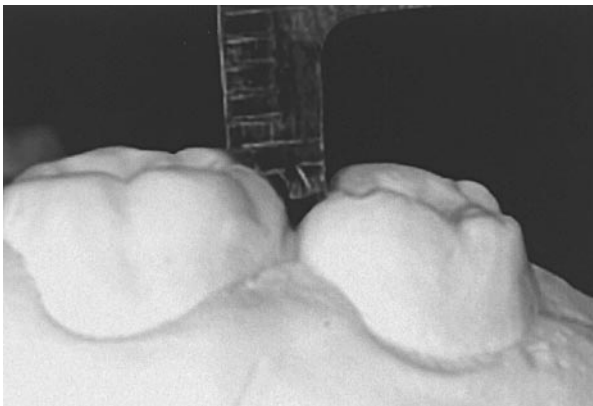


Fig 8

of previous field tests have shown that the most verifiable method of scoring this criteria is to use Angle's relationship. Therefore, the buccal cusps of the maxillary molars, premolars, and canines must align within 1 mm of the interproximal embrasures of the mandibu-

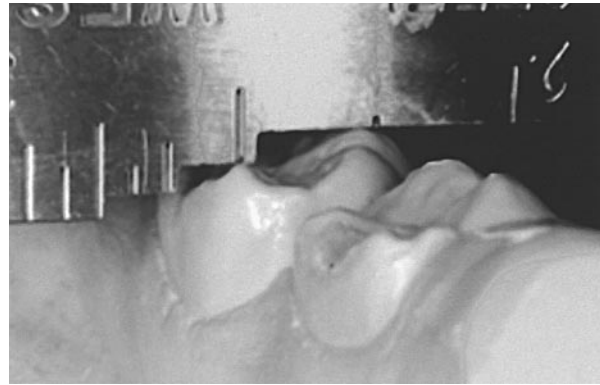


Fig 9

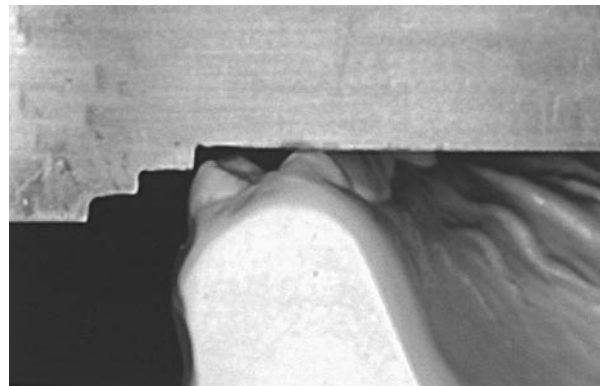


Fig 10

lar posterior teeth. The mesiobuccal cusp of the maxillary first molar must align within 1 mm of the buccal groove of the mandibular first molar.

Occlusal Contacts

Occlusal contacts are measured to assess the adequacy of the posterior occlusion. Again, a major objective of orthodontic treatment is to establish maximum intercuspation of opposing teeth. Therefore, the functioning cusps are used to assess the adequacy of this criterion, ie, the buccal cusps of the mandibular molars and premolars and the lingual cusps of the maxillary molars and premolars. If cusp form is small or diminutive, that cusp is not scored. In past field tests, the most common problem area has been inadequate contact between maxillary and mandibular second molars.

Overjet

Overjet is used to assess the relative transverse relationship of the posterior teeth and the anteroposterior relationship of the anterior teeth. In the posterior region, the mandibular buccal cusps and maxillary lin-

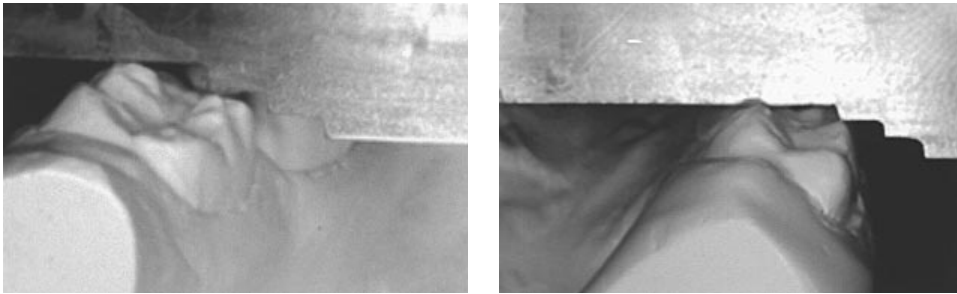


Fig 11

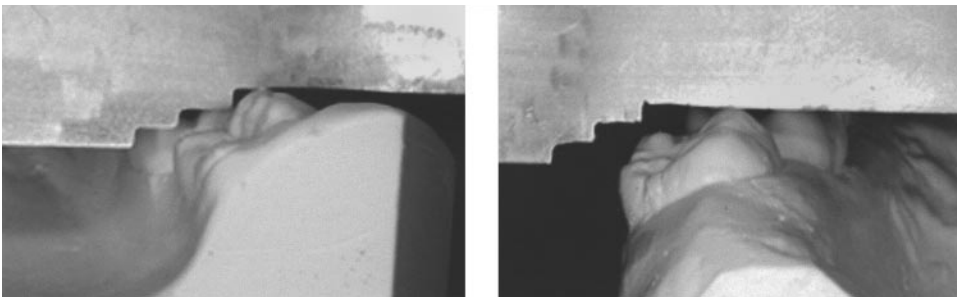


Fig 12



Fig 13



Fig 14

gual cusps are used to determine proper position within the fossae of the opposing arch. In the anterior region, the mandibular incisal edges should be in contact with the lingual surfaces of the maxillary anterior teeth. In past field tests, the common mistakes in overjet have occurred between the maxillary and mandibular incisors and second molars.

Interproximal Contacts

Interproximal contacts are used to determine if all spaces within the dental arch have been closed. Persistent spaces between teeth after orthodontic therapy are not only unesthetic, but can lead to food impaction. In

past field tests, spacing is generally not a major problem with ABO cases.

Root Angulation

Root angulation is used to assess how well the roots of the teeth have been positioned relative to one another. Although the panoramic radiograph is not the perfect record for evaluating root angulation, it is probably the best means possible for making this assessment. If roots are properly angulated, then sufficient bone will be present between adjacent roots, which could be important if the patient were susceptible to periodontal bone loss at some point in time.

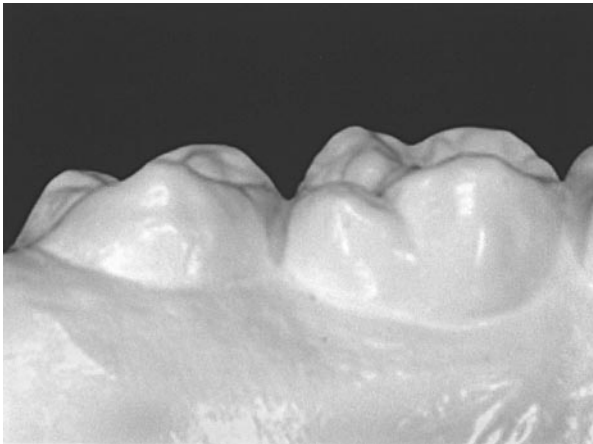


Fig 15

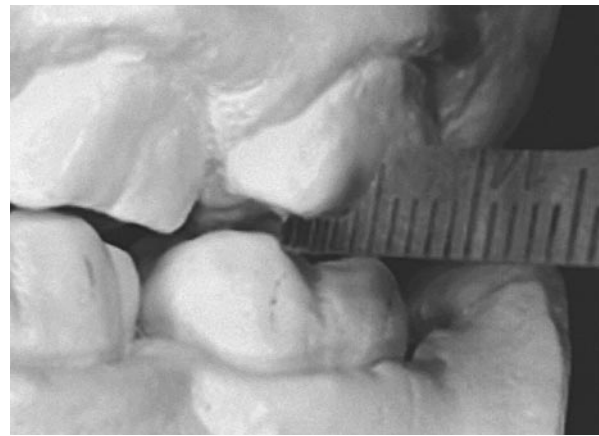


Fig 17

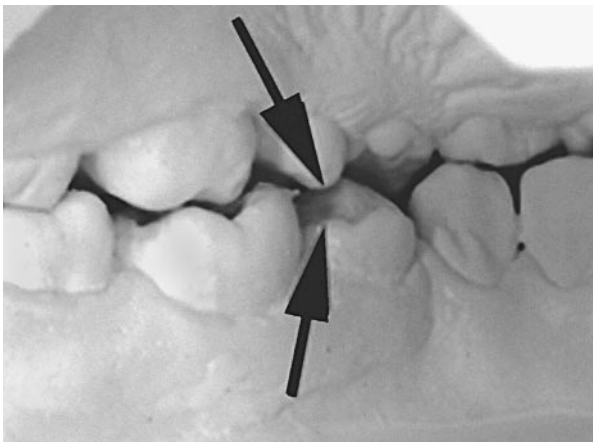


Fig 16



Fig 18

If roots are dilacerated, then they are not graded. In past field tests, the common mistakes in root angulation occurred in the maxillary lateral incisors, canines, and second premolars and mandibular first premolars.

GUIDE FOR GRADING CLINICAL CASE REPORTS Model Analysis

Alignment. In the maxillary and mandibular anterior regions, proper alignment is characterized by coordination of alignment of the incisal edges and lingual incisal surfaces of the maxillary incisors and canines (Fig 1), and the incisal edges and labial incisal surfaces of the mandibular incisors and canines (Fig 2).

In the mandibular posterior quadrants, the mesio-buccal and distobuccal cusps of the molars and premolars should be in the same mesiodistal alignment. In the maxillary arch, the central grooves (mesiodistal) should all be in the same plane or alignment (Fig 3). If all teeth are in alignment or within 0.50 mm of

proper alignment, no points are subtracted from the candidate's score. If the mesial or distal alignment at any of the contact points is 0.50 mm to 1 mm deviated from proper alignment (Fig 4), 1 point shall be subtracted for the tooth that is out of alignment. If adjacent teeth are out of alignment, then 1 point should be subtracted for each tooth. If the discrepancy in alignment of a tooth at the contact point is greater than 1 mm, then 2 points shall be subtracted for that tooth (Fig 5). No more than 2 points shall be subtracted for any tooth. The total number of deductions shall be subtracted from 64 to give the score for alignment.

Marginal ridges. In both maxillary and mandibular arches, marginal ridges of adjacent posterior teeth shall be at the same level or within 0.50 mm of the same level (Fig 6). If adjacent marginal ridges deviate from 0.50 to 1 mm (Fig 7), then 1 point shall be subtracted for that interproximal contact. If the marginal ridge discrepancy is greater than 1 mm (Fig 8), then 2 points shall be subtracted for that interproximal contact. No more than 2 points will be subtracted for any contact

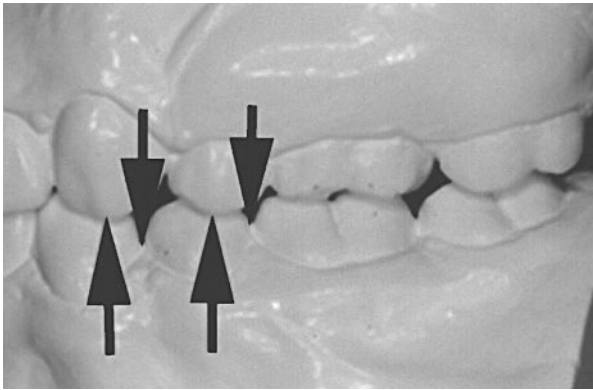


Fig 19



Fig 21

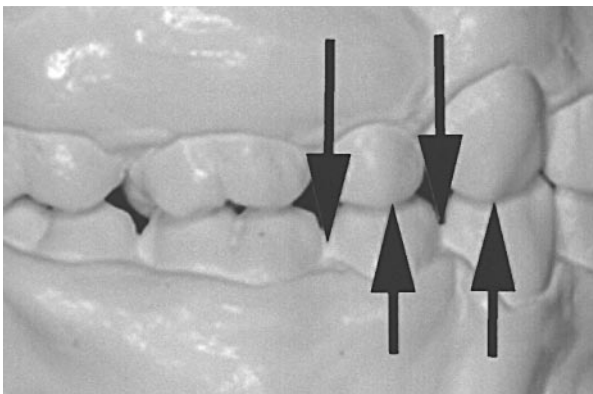


Fig 20



Fig 22

point. The marginal ridge will be considered as the most occlusal point that is within 1 mm of the contact at the occlusal surface of adjacent teeth. The total number of deductions shall be subtracted from 32 to give the score for marginal ridges.

Buccolingual inclination. The buccolingual inclination of the maxillary and mandibular posterior teeth shall be assessed by using a flat surface that is extended between the occlusal surfaces of the right and left posterior teeth. When positioned in this manner, the straight edge should contact the buccal cusps of contralateral mandibular molars. The lingual cusps should be within 1 mm of the surface of the straight edge (Fig 9). In the maxillary arch, the straight edge should contact the lingual cusps of the maxillary molars and premolars. The buccal cusps should be within 1 mm of the surface of the straight edge (Fig 10). If the mandibular lingual cusps or maxillary buccal cusps are more than 1 mm, but less than 2 mm from the straight edge surface (Fig 11), 1 point shall be subtracted for that tooth. If the discrepancy is greater than 2 mm (Fig 12), then 2 points are subtracted for that tooth. No more than 2 points shall be subtracted for any tooth. The total num-

ber of deductions are subtracted from 40 to give the score for posterior inclination.

Occlusal contacts. This section of the evaluation determines the adequacy of occlusal contact of the premolars and molars. The buccal cusps of the mandibular premolars and molars (Fig 13) and the lingual cusps of the maxillary premolars and molars (Fig 14) should be contacting the occlusal surfaces of the opposing teeth. Each mandibular premolar has one functional cusp. Each mandibular molar has two functional buccal cusps. The maxillary premolars have one functional lingual cusp. However, the maxillary molars may have only a mesiolingual functional cusp. If the distolingual cusp is short or diminutive (Fig 15), it should not be considered in the evaluation. If this cusp is prominent but does not contact with the opposing arch, then points may be deducted. If the cusps are in contact with the opposing arch, no points are deducted. If a cusp is out of contact with the opposing arch and the distance is 1 mm or less (Fig 16), then 1 point is subtracted for that tooth. If the cusp is out of contact and the distance is greater than 1 mm (Fig 17), then 2 points are subtracted for that tooth.

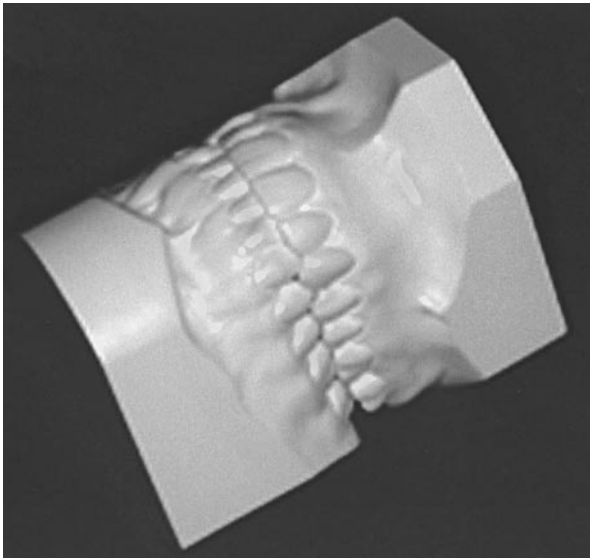


Fig 23



Fig 24

No more than 2 points are subtracted for each tooth. The total number of deductions are subtracted from 64 points to give the score for occlusal contacts.

Occlusal relationship. This section of the evaluation determines whether the occlusion has been finished in an Angle Class I relationship. Ideally, the maxillary canine cusp tip should align with or within 1 mm of the embrasure or contact between the mandibular canine and adjacent premolar (Fig 18). The buccal cusps of the maxillary premolars should align with or be within 1 mm of the interproximal contacts between the mandibular premolars and first molar (Fig 18). The mesiobuccal cusps of the maxillary molars should align with the buccal grooves of the mandibular molars (Fig 18). If the maxillary buccal cusps deviate between 1 and 2 mm from the aforementioned positions (Fig 19), then 1 point shall be subtracted for that tooth. If the buccal cusps of the maxillary premolars or molars deviate by more than 2

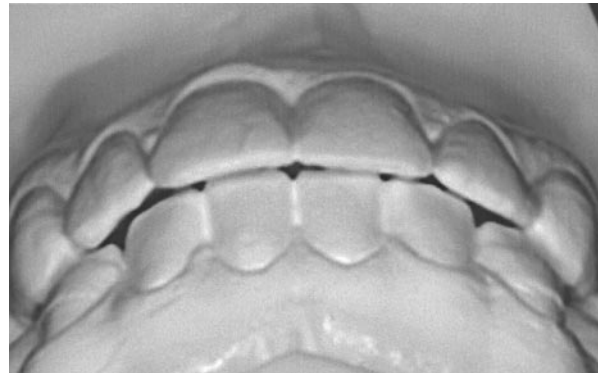


Fig 25

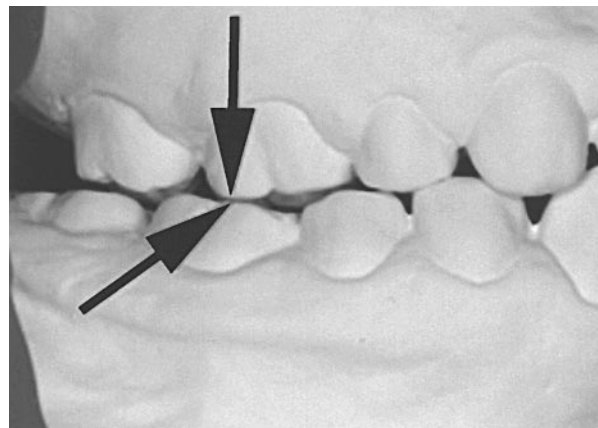


Fig 26

mm from ideal position (Fig 20), then 2 points shall be subtracted for each tooth that deviates. No more than 2 points shall be subtracted for each tooth. The total number of deductions are subtracted from 24 to give the score for occlusal relationships. In some situations, the posterior occlusion may be finished in either an Angle Class II or Class III relationship, depending on the type of tooth extraction in the maxillary or mandibular arches. In a Class II situation (Fig 21), the buccal cusp of the maxillary first molar should align with the embrasure or interproximal contact between the mandibular second premolar and first molar. The buccal cusp of the maxillary second molar should align with the embrasure or interproximal contact between the mandibular first and second molars. If the final occlusion is finished in a Class III relationship (when mandibular premolars are extracted), the buccal cusp of the maxillary second premolar should align with the buccal groove of the mandibular first molar (Fig 22). The remaining occlusion distal to the maxillary second premolar and mandibular first molar are adjusted accordingly.

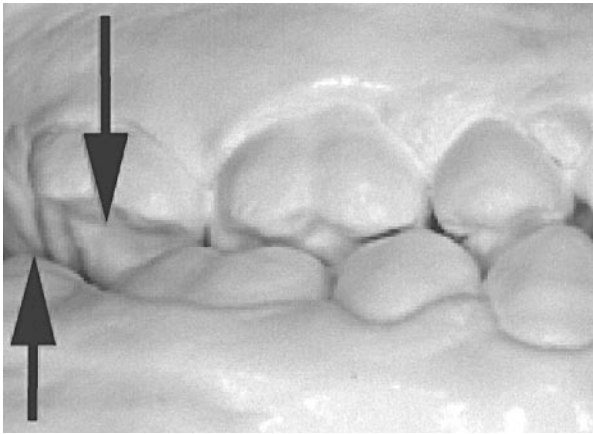


Fig 27

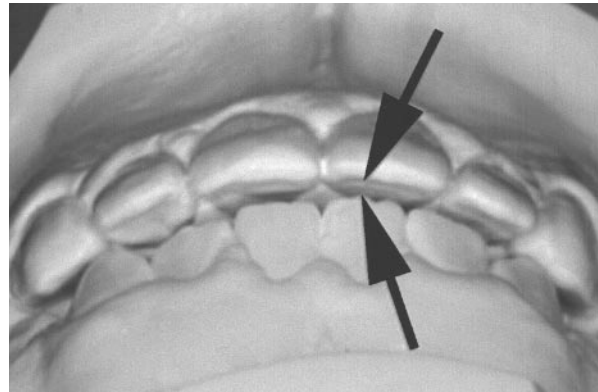


Fig 29

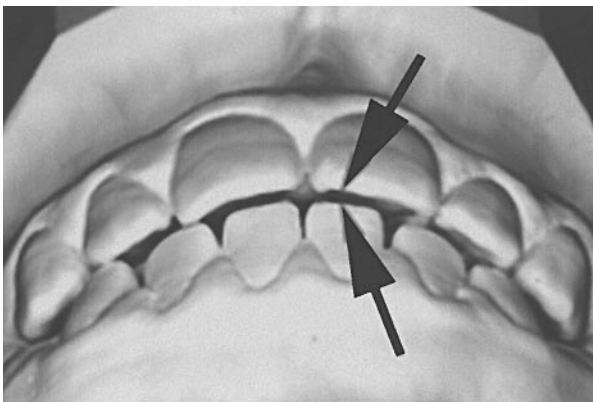


Fig 28

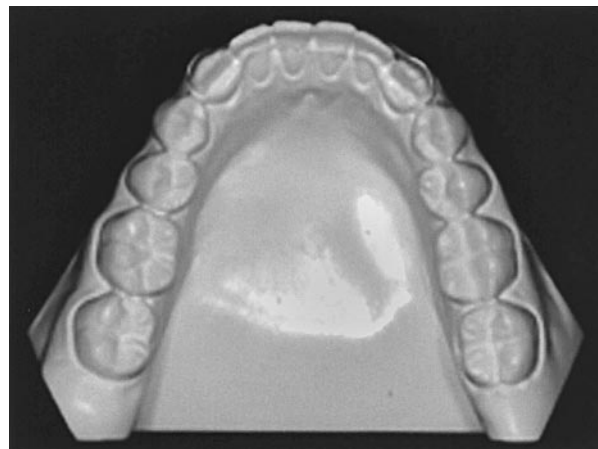


Fig 30

Overjet. The overjet is evaluated by articulating the models and viewing the labiolingual relationship of the maxillary arch relative to the mandibular arch. In order to determine the proper relationship of the casts, the examiner must rely on the trimming of the backs of the bases of the models. The models are set flat on their backs, in order to determine this assessment (Fig 23). If the models are mounted on an articulator, then the articulated mounting shall determine the proper maxillary and mandibular model relationship. If the proper overjet has been established, then the buccal cusps of the mandibular molars and premolars will contact in the center of the occlusal surfaces, buccolingually, of the maxillary premolars and molars (Fig 24). In the anterior region, the mandibular canines and incisors will contact the lingual surfaces of the maxillary canines and incisors (Fig 25). If this relationship exists, no points are subtracted. If the mandibular buccal cusps deviate 1 mm or less from the center of the opposing tooth (Fig 26), 1 point is subtracted for that tooth. If the position of the mandibular buccal cusps deviates more than 1 mm from the center of the opposing tooth (Fig 27), two points are

subtracted for that tooth. No more than 2 points are subtracted for any tooth. In the anterior region, if the mandibular canines or incisors are not contacting lingual surfaces of the maxillary canines and incisors and the distance is 1 mm or less (Fig 28), then 1 point is subtracted for each tooth. If the discrepancy is greater than 1 mm (Fig 29), then 2 points are subtracted for each tooth. The total number of deductions are subtracted from 32 to give the score for overjet.

Interproximal contacts. This assessment is made by viewing the maxillary and mandibular dental casts from an occlusal perspective. The mesial and distal surfaces of the teeth should be in contact with one another (Fig 30). If no interproximal spaces exist, then no points are subtracted. If up to 1 mm of interproximal space exists between two adjacent teeth (Fig 31), then 1 point is subtracted for that interproximal contact. If more than 1 mm of space is present between two teeth (Fig 32), then 2 points are subtracted for that interproximal contact. No more than 2 points are subtracted for any contact that deviates from ideal. The

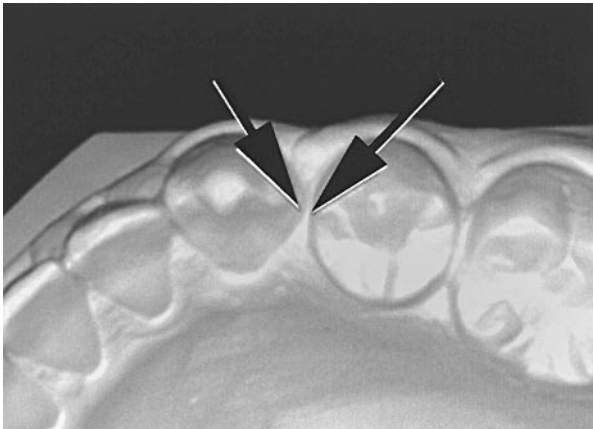


Fig 31

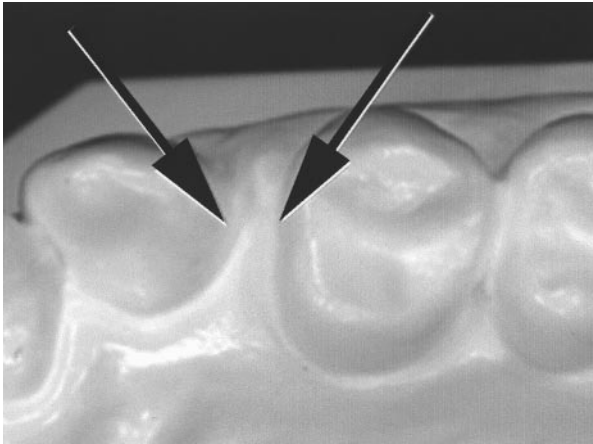


Fig 32

total number of deductions are subtracted from 60 to give the score for interproximal contacts.

Radiographic Analysis

Root angulation. The relative angulation of the roots of the maxillary and mandibular teeth are assessed on the panoramic radiograph. Although this is not ideal, it gives a reasonably good assessment of root position. Generally, the roots of the maxillary and mandibular teeth should be parallel to one another and oriented perpendicular to the occlusal plane (Fig 33). If this situation exists or if a deviation of the apex is 1 mm or less, then no points are subtracted. If a root is angled to the mesial or distal on the panoramic radiograph and if the discrepancy is mild with the apex of the affected tooth greater than 1 mm but less than 2 mm from its ideal relationship (Fig 34), then 1 point is subtracted for that tooth. If the discrepancy is greater than 2 mm (Fig 35), then 2 points are subtracted for that tooth. The total number of deductions are subtracted from 64 to give the score for root angulation.



Fig 33

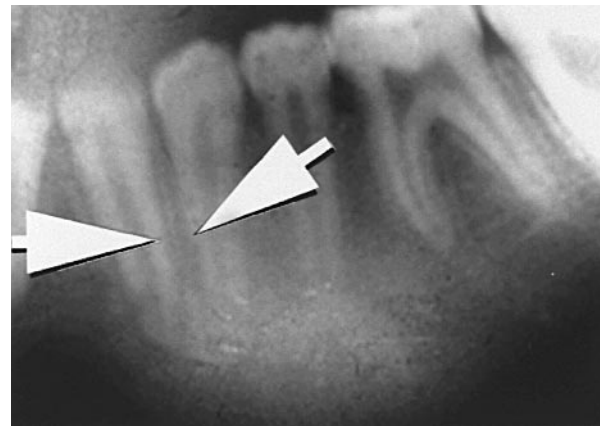


Fig 34

PASSING SCORE

During the 1997 and 1998 field tests, both subjective and objective methods of scoring the dental casts and panoramic radiographs were used by the directors. Based on a comparison of these two methods, a passing score was established. In general, a case report that loses more than 30 points will fail. A case report that loses less than 20 points will generally pass that portion of the phase III examination. However, this figure only represents a part of the overall score for each case report. The quality of the records, appropriateness of the treatment plan, and objectives for positioning of the maxilla, mandible, maxillary dentition, mandibular dentition, and facial profile are also carefully scrutinized. The Board is presently field testing objective methods for grading these other aspects of the phase III examination.

SUMMARY

The Directors of the American Board of Orthodontics have spent countless hours developing this system for assessing the occlusal and radiographic results of orthodontic treatment. The usefulness of this system

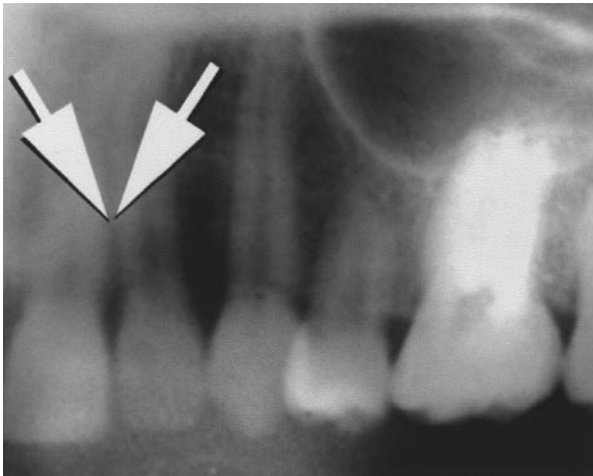


Fig 35

depends not only on its objectivity, but more importantly on the validity and reliability of the measurements. After repeated comparison of both objective and subjective systems, the Directors are confident that the “cut-off” score to pass this portion of the phase III examination is valid. Reliability will be insured through the use of a precise measuring instrument (Fig 36), in addition to training and calibration of the Directors before each examination. In order to be fair to all candidates, a confidence interval will be established to account for interrater variability.

Although the underlying purpose of establishing this grading system is to insure reliable and objective evaluation of orthodontic records, the Board sees a much greater benefit to publishing this grading system. In the future, candidates may grade their own results before the phase III examination. Candidates will know if their results will pass the CCRE portion of the phase III examination. Furthermore, diplomates may use this scoring system at anytime in their orthodontic career to

ABO MEASURING GAUGE

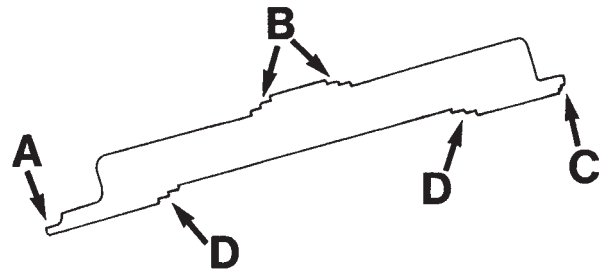


Fig 36. ABO measuring gauge. **A**, 1 mm in width and measures discrepancies in alignment, overjet, occlusal contact, interproximal contact, and occlusal relationships; **B**, steps measure 1 mm in height and are used to determine discrepancies in mandibular posterior buccolingual inclination; **C**, steps measure 1 mm in height and are used to determine discrepancies in marginal ridges; **D**, steps measure 1 mm in height and are used to determine discrepancies in maxillary posterior buccolingual inclination.

determine if they are producing “Board quality” results. The Board hopes that this method of self-evaluation will help to elevate the quality of orthodontic care in the future.

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