The Evaluation of Arch Form and Occlusion in Unilateral Cleft Palate Subjects

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The dental occlusion has been used in a number of studies to evaluate the results of cleft palate treatment, the success or failure of treatment usually being related to the frequency with which crossbites appear in the sample studied (*1*).

Two examples of occlusal classifications used for this purpose are those of Pruzansky and Aduss, 1964 (*2*) and Matthews et al. 1970 (*3*).

Pruzansky divided the occlusion into six categories:

(1) no crossbite present,
(2) canine crossbite only,
(3) buccal crossbite only,
(4) anterior and buccal crossbite,
(5) anterior and canine crossbite,
(6) incisor crossbite only.

In contrast, Matthews et al. 1970 (*3*) divided the occlusion into:

(1) Class A—where all the segments of the maxilla are in normal occlusion with the mandible.
(2) Class B (1)—the tooth bordering the cleft on the lesser segment is in lingual occlusion.
(3) Class B (2)—normal occlusion of the greater segment but lingual occlusion of the lesser segment.
(4) Class B (3)—the maxillary arch is perfect but is too small.
(5) Class C—an overall Class III occlusion of all segments of the maxilla and, in addition, collapse of some part of the small maxillary arch.

Although both classifications describe the occlusion, the categories used are so dissimilar that effective comparison of the results is extremely difficult. Nevertheless, such comparisons must be able to be made if cleft palate treatment is eventually to be rationalised. Even assuming, however, that all investigators use the same classification in the interest of comparability, two further problems emerge:

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(1) What is the most satisfactory classification?
(2) How reliable would this be in the hands of different observers who might find difficulty in establishing common assessment criteria?

While investigating the results of presurgical maxillary orthopaedic treatment using a descriptive classification, the authors noticed that not only did their assessments of the cases differ between themselves, but that the assessment of a particular case by the same observer on different days also varied.

This was resulted from the fact that although the classification contained clearly defined categories, this sharp delineation did not extend to the occlusion and a great deal of subjective judgement had to be employed when using it.

Because the authors had every opportunity to establish common assessment criteria, the presence of such variations tended to suggest that these might be much greater if the investigators worked independently with only indirect communication with each other.

It was decided therefore to investigate the reliability of occlusal assessments by different observers using the same classification and to examine the consistency of the results obtained by each observer when making repeated assessments of the same case.

To increase the scope of the investigation, the ability to assess arch form was also studied because of its importance when evaluating the effects of different methods of treatment on the maxillary arch.

For the investigation, the descriptive classification of Pruzansky and Aduss 1964 (*2*) already described was used, the occlusions being placed in one of the six categories.

The difficulties of categorizing an occlusion not showing the sharp delineation required by the classification have already been mentioned. However, two further criticisms of descriptive classifications are:

(1) while they describe malocclusions they do not consider their extent. It is therefore difficult to rank a group of cases in order of severity.
(2) the classifications being non-numerical would make statistical analysis of results difficult.

An alternative numerical classification developed by the authors was also investigated to see whether it possessed any advantages over the descriptive type.

Material and Method

The material consisted of upper and lower plaster models of 34 unilateral cleft lip and palate subjects aged 5 years (average 4 years 51 weeks) from the records of the Birmingham Regional Plastic Unit. All the cases in the Unit which satisfied the following criteria were included in the investigation:

(1) the original condition had to be a complete unilateral cleft of the lip, alveolus and palate.

(2) there had to be a complete deciduous dentition with no teeth missing except possibly the deciduous lateral incisor in the region of the alveolar cleft.

(3) the occlusion of the models had to be clearly marked.

Following surgical repair of the lip and palate, no appliance of any kind was worn prior to the impressions being taken nor was any bone grafting, either primary or secondary, carried out.

The 34 sets of models were examined in turn by 11 assessors, all trained orthodontists and classified according to:

(1) the Pruzansky descriptive classification of occlusion,

(2) the authors' numerical classification of occlusion,

(3) the maxillary arch form, to establish whether there was: (a) good segmental alignment (Figure 1 top) or (b) segmental overlap (Figure 1 bottom).

As applied to the deciduous occlusion which formed the basis of the investigation, the authors' numerical classification divided the maxillary arch into two buccal segments (consisting of the canine and first and second deciduous molars) and a labial segment (consisting of the two deciduous central incisors) (Figure 2).

In the labial segment, the deciduous lateral incisors were not assessed as they were often absent or unreliable in their position.

Each tooth was awarded a number of points depending on its position relative to its opponent in the lower jaw (Figure 3) and in this way, a total score obtained for each of the three segments.

As seen from Figure 3, the buccal occlusion on one side had a possible score varying from 0 for a normal bucco-palatal relationship to −6 if the canine and both deciduous molars were in crossbite.

When the score fell between these two extremes, the single number was considered to give a more accurate index of the extent of the discrepancy than the simple categorization of the descriptive classification.

For example an occlusion with /CDE in complete crossbite and another with /C in crossbite, /D cusp to cusp and /E in normal relation, could both be described as having a buccal and canine crossbite using the descriptive classification but their score would be −6 and −3 respectively, using the numerical classification.

In the investigation, the assessors worked independently and there was no verbal or written communication between them.

All 34 models were given to each assessor in turn to be evaluated in any order. To see whether it was possible to establish comparable assessment criteria by reference to literature alone, a comprehensive set of written instructions relating to the assessment of arch form and the authors' numerical classification was enclosed with the models.

With regard to the Pruzansky descriptive classification, the assessors were asked the read the articles by Pruzansky and Aduss, 1964 (*2*) and Bergland, 1967 (*4*) to obtain the relative information.

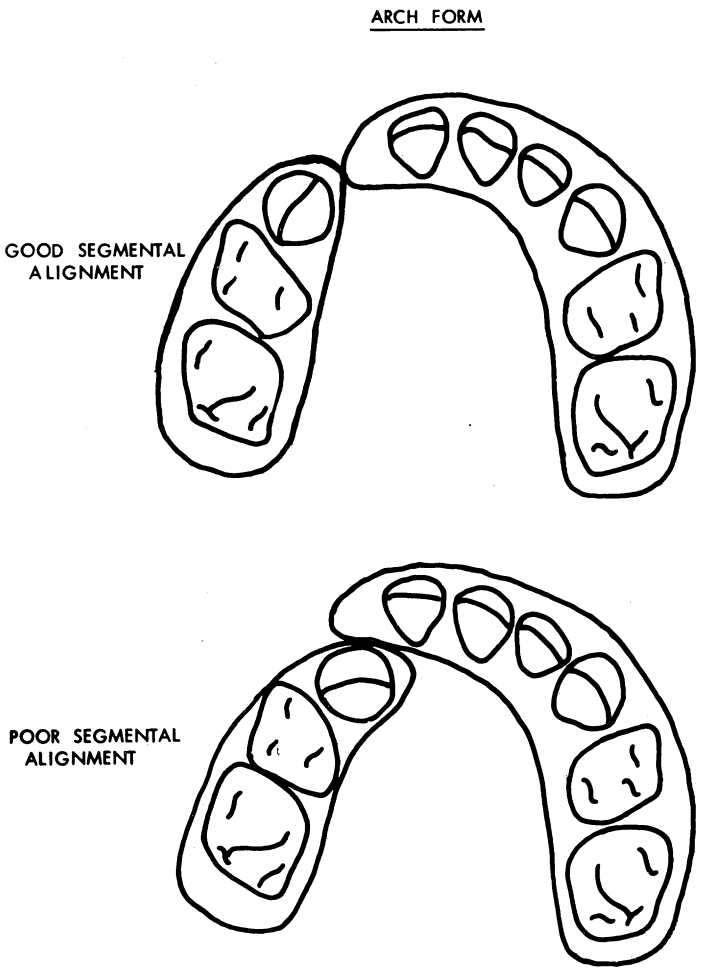

FIGURE 1. Arch alignment. Diagrammatic illustration of good segmental alignment. There may or may not be actual contact of the greater and lesser segments. The lower diagram illustrates poor segmental alignment with a contracted arch form. There is overlapping and contact of the greater and lesser segments.

The assessors were requested to examine each set of models three times, each time on a separate day and to record their results on specially prepared sterotyped sheets.

In the course of the investigations, each pair of models was evaluated 33 times, (i.e. 3 × 11 observers), following which the data was statistically analysed.

This analysis aimed at establishing the following with respect to the descriptive, numerical and arch form classifications used:

(1) The classification of the whole group of 34 cases as agreed by a majority of the assessors.

(2) The consistency of the assessments (that is to say, the extent of variation between different assessments of the same assessor).
(3) The reliability of the assessments, (that is to say how closely the assessments of the individual assessor agreed with those of the 11 assessors combined).
(4) The ease with which statistical processes could be applied to the data.

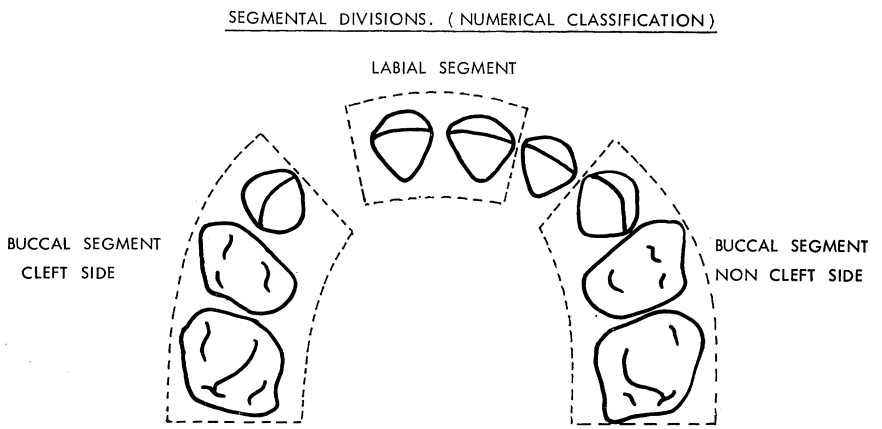

FIGURE 2. Numerical classification. Subdivision of the deciduous maxillary arch into three segments. Each buccal segment consists of the canine and first and second molars whilst the labial segment consists only of the two central incisors.

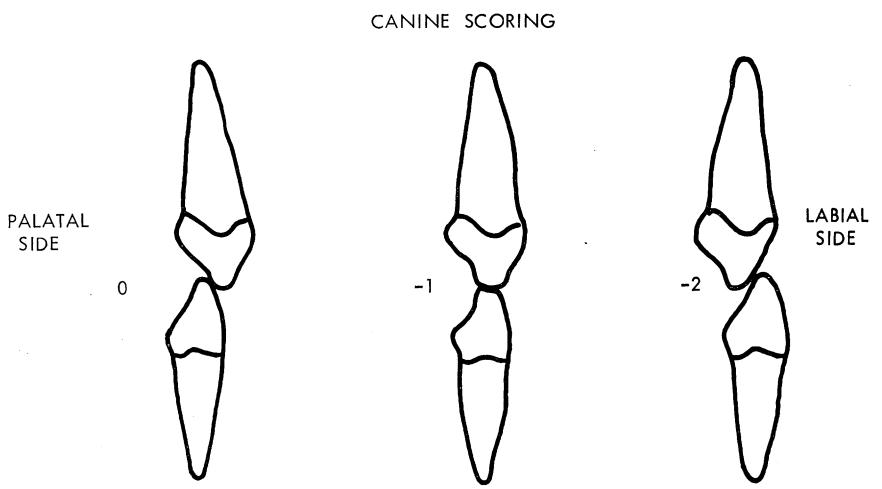

FIGURE 3. Numerical classification. Occlusal scoring of the deciduous maxillary arch. (a) Scoring of the labio-palatal relationship of the canines; (b) Scoring of the bucco-palatal relationship of the molars. Both the first and second deciduous molars are assessed for purposes of classification; (c) Scoring of the antero-posterior relationship of the central incisors. A large upper incisor overjet may warrant a score greater than +1.

MOLAR SCORING

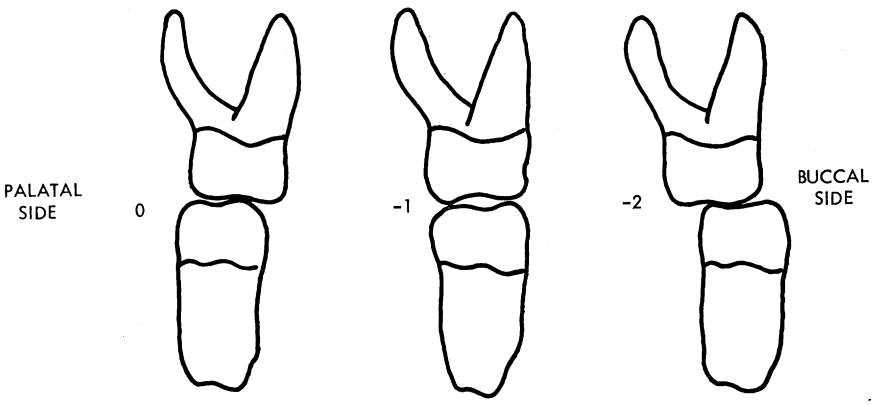

FIGURE 3b

INCISOR SCORING

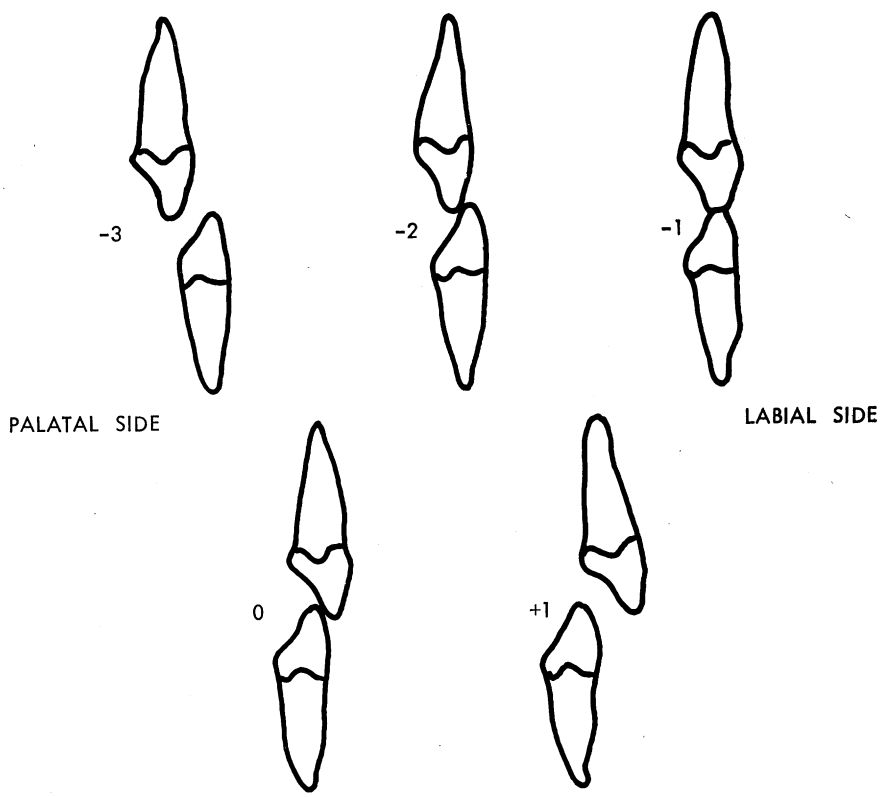

FIGURE 3c

Results

1. Classification

(A) Descriptive Classification (Table 1). Because of the multiple assessments made by each observer, the classification of the 34 cases as a single group could be done in two ways:

(a) by reference to the categorization of the individual cases (Table 1, line A). Each case was classified according to which category received the most assessments (maximum possible in any single category = 3 × 11 = 33). While some cases were unanimously consigned to a particular column, others barely received a majority (e.g. case 84 was classified as having a buccal crossbite with only 51.52% of the possible assessments).

(b) by reference to the total number of assessments made, (i.e. 33 × 34 = 1122) irrespective of to which case they referred (Table 1, line B). This was because a particular case was not necessarily consigned to the same category on each of the three occasions on which it was examined by a particular assessor.

(B) Numerical Classification (Table 2). The average crossbite scores for the 34 cases are given in Table 2 and these are equivalent approximately to the following:

(1) Cleft side buccal segment. The score of −3.98 is approximately equivalent to the deciduous maxillary canine in lingual occlusion and the first and second deciduous molars in cusp to cusp occlusion with the lower arch.

(2) The non-cleft side buccal segment. The score of −0.72 is equivalent to the maxillary canine tending to be in a cusp to cusp relationship to the lower canine, although the tendency is not marked.

TABLE 1. Classification. Descriptive method. Classification of the entire group by: (A) classification of the individual cases (B) the total number of assessments made.

Line A shows the number of *cases* (given in brackets) in each category expressed as a percentage of the total examined, (i.e. of 34 cases). Line B gives the number of times an *assessment* fell into a particular category expressed as a percentage of the total number of assessments made, (i.e. of 34 × 33 = 1122). For example, 11.8% of the cases had no crossbite (column (a)) but only 8.8% of the total assessments were in this category. With respect to anterior crossbite (column (f)) however, whilst 1.5% of the assessments were in this category, (line B) none of the cases was in fact classified as such (line A) because in no case did this category receive a majority of the assessments.

	No crossbite (a)	Canine only crossbite (b)	Buccal crossbite (c)	Ant. & Buccal crossbite (d)	Ant. & Canine crossbite (e)	Anterior crossbite (f)
A	11.8% (4)	11.8% (4)	29.4% (10)	38.2% (13)	8.8% (3)	- (0)
B	8.8%	11.4%	29.77%	40.64%	7.5%	1.5%

TABLE 2. Classification. Numerical method. The average segmental scores and average total occlusal score for the whole group of 34 cases are given, together with their standard deviations.

	BUCCAL SCORE		INCISOR SCORE	TOTAL OCCLUSAL SCORE
	Cleft side	Non-cleft side	A/A only	
Average of 34 cases	-3.98	-0.72	-2.06	-6.76
Standard Deviation	1.71	1.68	1.73	3.88

(3) The incisor segment. The score of −2.06 is equivalent to A/A being in edge to edge occlusion with the lower incisors.

(4) The total occlusion. The overall score of −6.76 is equivalent to the total crossbite malocclusion detailed in (1) (2) and (3) above.

(C) Arch Form (Table 3). The classification of the group as a whole could be done in two ways:

(i) on the basis of the classification of the individual cases (Table 3 line A). As with the descriptive classifications, some cases were unanimously categorized, whilst in others, the observers were almost evenly divided as to which category should receive them.

(ii) on the basis of the number of assessments of good segmental alignment or segmental overlap regardless of the case to which they refer (Table 3 line B).

2. Observer Consistency

(A) Descriptive Classification (Table 4). Each of the 11 assessors' results were examined individually, case by case. For each case, if the three assessments were in the same category, the assessor was awarded two points, but if only two were the same, the assessor was awarded one point. If each assessment in a particular case was in a different category, no points were awarded.

TABLE 3. Classification. Arch Form. The classification of the total case sample is given in percentage form in two ways: (A) on the basis of the classification of the individual cases. The number of cases in each category is given in brackets (100% = 34). (B) on the basis of the total assessments made regardless of the case to which they refer. (100% = 34 × 33 = 1122).

	Good segmental alignment	Segmental overlap
A Classification of group on the basis of the classification of the individual cases	73.5% (25)	26.9% (9)
B Classification of group on the basis of total assessments made regardless of to which case they refer	63.9%	36.1%

	Points awarded	% consistency
Average for all observers	56.6	83.29
Maximum	63	92.65
Minimum	49	72.06
Standard Deviation	4.17	6.19

TABLE 4. Observer Consistency. Descriptive Classification. The points awarded to the average observer for consistency (see text) is given, and this is also expressed as a percentage of 68 (the maximum number of points obtainable).

The number of points obtained by the average observer is given in Table 4 and this is expressed as a percentage of 68 (that is to say 2 × 34), the maximum number of points possible if there had been complete consistency.

(B) NUMERICAL CLASSIFICATION (TABLE 5). The results of each assessor were examined individually, case by case. For each case the assessments of the three segments were examined separately as was also the assessment of the total occlusal score.

If, in a particular case, the three readings for a specific segment or for the total occlusion were the same, the assessor was awarded 2 points, but if only two were the same, the assessor was awarded 1 point. If each of the readings were different, no points were awarded. The points obtained by the assessor in each category (i.e. the three segments and the total occlusion) for the 34 cases were then added together, each category being totalled separately.

The points awarded to the average observer for consistency in assessing the three segments and the total occlusion are given in Table 5 and these results are also expressed as percentages of 68 (i.e. 2 × 34), the maximum score possible if there had been complete consistency in assessing any one category.

(C) ARCH FORM (TABLE 6). Each assessors' results were examined individually and for every case in which the three assessments of arch form

TABLE 5. Observer Consistency. Numerical Classification. The number of points awarded for consistency to the average observer for each of the three segments and the total occlusion are given and these are also expressed as percentages of 68 (see text). Maximum and minimum values and standard deviations are also given.

	BUCCAL SEGMENTS				INCISOR SEGMENT		TOTAL OCCLUSION	
	Cleft side		Non-cleft side					
	Points awarded	% consistency	Points awarded	% consistency	Points awarded	% consistency	Points awarded	% consistency
Average observer	52.8	77.6	62.6	92.1	57.6	84.7	44.6	65.6
Maximum	61	89.7	66	97.1	65	95.6	57	83.8
Minimum	36	52.9	54	79.4	51	75.0	29	42.6
Standard Deviation	8.2	12.1	4.1	6.1	4.1	6.0	8.6	12.7

TABLE 6. Observer Consistency. Arch Form. The number of cases unanimously classified by the average observer is given and this is also expressed as a percentage of 34, (the maximum number if complete consistency were attained). The maximum and minimum figures are also given together with the standard deviations.

	Number of cases unanimously classified (points)	% consistency
Average for all observers	27.8	81.8
Maximum	33	97.1
Minimum	20	58.8
Standard Deviation	4.39	12.93

were identical, one point was awarded. The number of cases unanimously classified by the average observer is given in Table 6 and this is also expressed as a percentage of 34 (equivalent to complete consistency).

3. Observer Reliability

(A) Descriptive Classification (Table 7). Each observer's results were examined individually and the number of times his assessments coincided with the agreed categorization of the individual cases was found. The number of times the average observer agreed with the group categorization is given in Table 7 and this is also expressed as a percentage of 102. 100% reliability means that all his assessments, (i.e. $3 \times 34 = 102$) coincide with the agreed categorization.

(B) Numerical Classification (Table 8). A majority score for each individual case was obtained using the data from all the 11 observers. This was done by taking each of the three segments in turn and by examining each of the observer's scores for that segment, putting down the figure which occurred most frequently.

TABLE 7. Observer Reliability. Descriptive Classification. The number of times the average observer agreed with the majority classification of the cases is given and this is expressed as a percentage of 102 (i.e. 3×34 cases) the total number of assessments made by the individual assessor. Maximum and minimum values and standard deviations are also given.

	Number of times agreed with group (maximum 102)	% reliability
Average for all observers	81.3	79.7
Maximum	95	93.1
Minimum	60	58.8
Standard Deviation	9.32	9.14

TABLE 8. Observer Reliability. Numerical Classification. The points awarded for reliability to the average observer for each of the three segments and the total occlusion are given and these are also expressed as percentages of 102 (see text). The maximum and minimum values are also given together with the standard deviations.

	BUCCAL SEGMENTS				INCISOR SEGMENT		TOTAL OCCLUSION	
	Cleft side		Non-cleft side					
	Points Awarded	% reliability	Points Awarded	% reliability	Points Awarded	% reliability	Points Awarded	% reliability
Average observer	79.1	77.5	92.6	90.7	32.6	80.9	61.7	60.5
Maximum	94	92.2	93	96.1	92	90.2	78	76.5
Minimum	54	52.9	83	81.4	70	68.6	50	49.0
Standard Deviation	12.4	12.1	44	4.3	7.4	7.3	5.2	9.0

The number of times each observer agreed with this majority score for each of the three segments separately was then established (maximum score = 3 × 34 = 102 for each segment).

With regard to reliability in assessing the total occlusion this was calculated in a similar manner to the above except that the total occlusal score instead of the individual segmental scores was used in calculating the majority score for the individual case.

The number of times the average observer agreed with the majority scores is given in Table 8 and these are also expressed as percentages of 102, (the total number of assessments each observer makes).

(C) Arch Form (Table 9). Each observer's results were examined individually and every time an assessment of arch form coincided with the agreed assessment, one point was awarded. Table 9 gives the number of times the average observer agreed with the group assessment and expresses this as a percentage of 102.

TABLE 9. Observer Reliability. Arch Form. The number of times the average observer agreed with the majority assessment of arch form is given and this is expressed as a percentage of 102 (see text). Maximum and minimum values and standard deviations are also given.

	Number of times agreed with group (maximum 102)	% reliability
Average for all observers	79.6	78.0
Maximum	99	97.1
Minimum	69	67.6
Standard Deviation	8.00	7.88

Discussion

Although with the numerical classification the percentage reliability results when examining individual segments were similar to those obtained with the descriptive classification, if the total occlusion was considered, observer reliability and consistency was much lower.

This could be because of the fact that the descriptive classification required a case to be assigned to one of six categories. With the numerical classification, the same situation existed so far as the individual segments were concerned because the scores ranged from 0 to −6, but when the total occlusion was considered, the range was much greater, being the sum of the segmental scores and therefore extending from +2 to −18.

Having to place a case in one of 21 categories using the numerical classification* instead of only 6 with the descriptive, might well account for the lower consistency and reliability percentages already noted and it must be admitted therefore that the method of analysis perhaps dealt unduly harshly with the numerical classification.

Indeed, the difference of one point which separates one category from another in the numerical classification is only equivalent to one incisor tooth being in edge to edge instead of normal occlusion. The smallness of this difference is illustrated in Figure 4 where the incisor relationship shown could be interpreted with equal truth as being either normal or edge to edge.

Failure to agree with the majority findings however using the numerical classification only represented a difference in the degree of malocclusion thought to be present, whereas with the descriptive classification, lack of agreement implied that a difference in the fundamental type or nature of the malocclusion also existed. As the categories of the descriptive classification could not be ranked in any definite order however, the concept of "degree" as distinct from "type" of malocclusion could not be introduced so that it was impossible to assign a significance to these differences. It was, for example, impossible to decide whether a buccal crossbite was worse than an anterior crossbite.

In the light of the above, the results using the numerical classification were re-examined and new observer consistency and reliability figures calculated, this time based on the number of times the assessor came within ±1 of the agreed figure. When this was done, the observer consistency when assessing the total occlusion rose to 83.8% and reliability to 81.2% (compared with 83.29% and 79.7% respectively for the descriptive classification). If the latitude was increased to ±2 (equivalent to the two upper incisors being considered in edge to edge instead of normal occlusion), the observer consistency rose to 93.4% and reliability to 92.1%, both considerably higher than the descriptive classification.

When correlations were carried out between the reliability percentages

* A score of 0 also counts as one category.

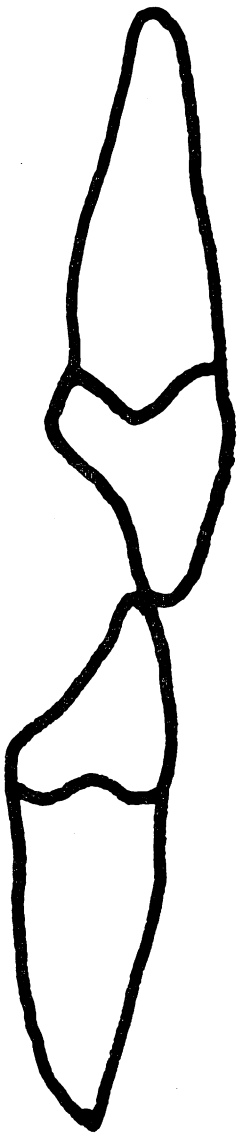

FIGURE 4. Ambiguous relationship of the upper and lower central incisors. The occlusion could equally well be classified as normal (score = 0) or edge to edge (score = −1) and such relationship supports the use of a ±1 latitude with the numerical classification.

achieved by the individual assessors using the two classifications, a correlation coefficient of 0.85 was obtained ($P < 0.001$). For the consistency percentages the correlation coefficient was 0.77 ($P < 0.01$). This indicates that although considerable differences exist in the assessment abilities of individual observers, their *relative* abilities do not alter when they change from one classification to another. An observer therefore with a high degree of consistency and reliability using one classification would also show a high degree of consistency and reliability using the other.

The variations observed in the reliability and consistency figures of the individual observers however did cause some concern and investigators might be well advised in the future to consider having their ability (i.e. their consistency and reliability) to observe and assess occlusions monitored before embarking on the type of studies considered here to increase the validity of their findings.

When categorizing an occlusion using the descriptive classification, the assessors were found to be most positive when assigning a case to the anterior and buccal crossbite category, cases being consigned there on average with 91.92% of the available assessments.

In contrast, the least definite categorization was found in cases of anterior and canine crossbite which, on average, only received 58.59% of the available assessments. This perhaps could indicate some difficulty on the part of the assessors in deciding exactly when a buccal segment was completely in crossbite and might thereby justify the use of the ± 1 degree of latitude which was applied to the numerical classification.

When investigating a group of cases using descriptive classifications, the results may be presented in two ways:

(1) Each individual case may be classified separately and the overall classification of the group obtained by calculating the percentage of *cases* which fall into a particular category or

(2) multiple assessments may be made of each case and the categorization of the whole group calculated by reference to the *assessments* only, without considering what the classification of a particular case might be.

This is shown particularly with respect to anterior crossbite where 1.5% of the assessments made by the 11 assessors fell into this category although in no instance did a case receive a majority of assessments in this category and therefore no case was actually designated as having an anterior crossbite (Table 1).

A similar discrepancy may be seen with regard to arch alignment.

In the present study 25 cases (73.5%) had good segmental alignment but only 63.9% of the assessments were in this category, (Table 3), because, on average, each *case* so classified had the support of 78.5% of the assessments, the remainder consigning it to the opposite category.

In the segmental overlap cases, these on average, were classified by 76.8% of their assessments so that the observers were marginally less definite about categorizing such cases. Perhaps in this respect the principle of the "benefit of the doubt" may have been applied so the assessors would not appear too harsh in their judgements. Even using multiple assessments, however, the incidence of good arch alignment considered to exist in the 34 cases as a whole varied from 41.8% to 83.33% depending on the observer, the mean being the 63.90% already mentioned.

The evaluation of arch form by an individual observer therefore, particularly if only one assessment is made of each case, must be considered

hopelessly inaccurate. Indeed, even with large numbers of observers and multiple assessments it is still very unreliable and probably some form of numerical classification will have to be developed to obtain meaningful results in future studies.

With regard to assessment of the occlusion, it is considered that in the light of its performance in the present investigation, some form of numerical classification is probably the classification of choice.

Using it, statistical procedures may be readily undertaken and given the degree of latitude discussed earlier, observer reliability and consistency are greater than with the descriptive classification. Furthermore, it takes into account the severity of the malocclusion, something which the descriptive does not.

From the results, it was calculated that a single observer making one assessment of the total amount of crossbite in a particular case using the numerical classification would come within ± 0.47 of a point in 95% of cases. For example, if his examination shows that a particular case has a total occlusal score of -6, this implies that in 95% of cases the true score for the crossbite would lie between -5.53 and -6.47 (equivalent to one incisor being in edge to edge instead of normal occlusion). Because of the inability to rank the descriptive classification, however, it is not possible to ascribe a value to the reliability of individual assessments made with it in this way, thus again underlining the advantages of the numerical classification where comparative occlusal studies between different cleft palate units are being undertaken.

Summary

The occlusions of 34 unilateral cleft lip and palate cases with intact deciduous dentitions at 5 years of age, were classified by 11 trained observers on three separate occasions using a descriptive classification and a numerical classification. At the same time, the maxillary arch form was assessed by describing the segments as being either in good alignment or overlapping.

The data was then analysed statistically to compare observer consistency and reliability using the two classifications and when assessing arch form.

With certain qualifications concerning the numerical classification, it was found that observer reliability and consistency were very similar no matter which classification was used. However, because the descriptive classification made no provision for assessing the extent of the malocclusion or for ranking different malocclusions in order of severity, it was considered the numerical classification was more suited for future studies in this field, particularly as it was easier to handle statistically. Furthermore, the numerical classification gave more detailed information about the occlusion than was possible with the descriptive.

Considerable differences were found to exist between the assessment

abilities of different observers regardless of the classification used and serious consideration must be given in future to monitoring the observational abilities of investigators about to embark on studies similar to the one described here. Indeed, the variations in the assessment of arch form were so great as to indicate the need for devising some form of numerical classification to describe segmental alignment in an effort to obtain more uniform findings.

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