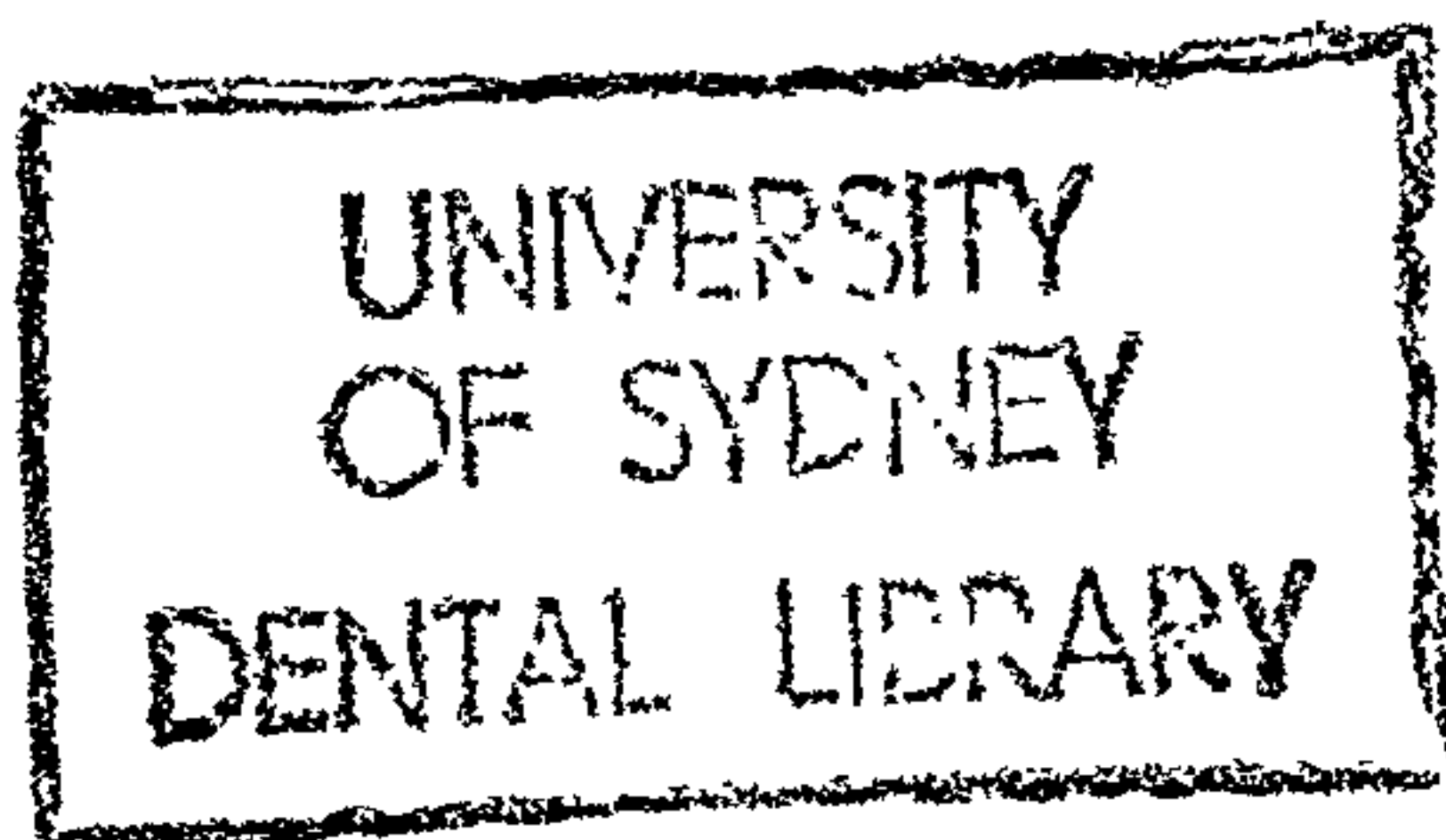


THE EFFECT OF FIXED ORTHODONTIC APPLIANCES
UPON THE GINGIVAL TISSUES.

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INTRODUCTION

In both periodontics and orthodontics there is a continuing interest in the effects of orthodontic therapy on the gingival tissues. Bacterial plaque seems to represent the single most important aetiological factor responsible for periodontal disease (Socransky, 1970).

Zachrisson (1976), presented his findings of iatrogenic effects of fixed orthodontic appliances on the gingiva. The author concluded that "the most important factor in the destructive process of periodontal breakdown is the bacterial plaque at the gingival margin." The author's histopathological observations indicated that the gingival changes represented a reaction to the bacterial plaque products rather than to the orthodontic forces. The author demonstrated that there is a direct relationship between oral hygiene and gingivitis.

Fixed orthodontic appliances have been cited as a predisposing cause of gingival disease. This, it has been suggested, is because of their mechanical irritant effect, or because of their increased plaque retention potential.

The evidence suggests that any damaging effect on the gingival tissues in the presence of fixed appliances is largely due to increased plaque retention.

It may be conjectured that, if orthodontic appliances do contribute to periodontal disease, their removal should allow improved plaque control, and help to reverse the process of periodontal disease.

It is the purpose of this study to assess the effect of fixed orthodontic appliances and plaque accumulation upon the health status of the gingival tissues.

A. REVIEW OF THE LITERATURE

1. FIXED APPLIANCES RELATED TO GINGIVITIS

(A) EARLY OBSERVATIONS OF THE EFFECT OF ORTHODONTIC APPLIANCES ON THE GINGIVAL TISSUES.

As early as 1924 Castro noted the importance of prophylactic care of the mouth during orthodontic management. He observed the necessity of careful adjustment and management of orthodontic appliances to prevent gingival irritation.

The gingival inflammation and changes which occurred as a result of ill-fitting orthodontic band placement was also noted by Bodecker and Applebaum (1934). These authors also questioned whether the continual presence of well-placed bands may not cause an inflammation of the gingiva.

Both Stuteville (1938), and Meyer (1940), claimed that trauma from orthodontic appliances can cause injuries to the teeth and supporting tissues; and the structures which may be affected include the gingiva. Stuteville confirmed the findings of Castro (1924), and Bodecker et al. (1934), but stated that all the injuries to the teeth and gingiva can be prevented by properly designed and constructed appliances; and injury by food particles can be prevented by thorough cleaning of the teeth after every meal.

Additional evidence that the movement of teeth with orthodontic appliances can cause gingivitis was provided by Skillen (1940) and Spence (1955).

The advent of modern fixed orthodontic appliance therapy, and the better appreciation of the disease process has helped to bring about a reduction in the gingival inflammation attributed to faulty design, construction and management of these earlier appliances.

Dummett (1951), in discussing orthodontic cases, noted that orthodontic appliances can produce areas of local gingivitis. He suggested that well-fitting and well-adjusted appliances can drastically reduce these gingival disturbances. However, he did not suggest that well-fitting and adjusted appliances will prevent gingival inflammation even in hygienic mouths.

Glickman (1953), reported that a major factor relating the gingival status to orthodontic appliances was oral hygiene. This emphasis on gingival health and oral hygiene is supported by Woods (1955) and Burkett (1963), who showed the importance of tooth brushing in maintaining a normal gingiva during orthodontic treatment.

Woods also observed that the accumulated debris which lodges around poorly cleaned orthodontic appliances acts as an irritant to the supporting structures. His clinical evidence indicated that the irritant effect was an inflammation of the gingiva.

Arnim and Williams (1959) and Arnim and Sandell (1961), in supporting the viewpoint of Woods, indicated that the bacterial plaque is an important causative irritating agent responsible for gingival inflammation. Therefore, it may be that instead of causing direct irritation of the tissues, the orthodontic appliances furnish a favourable environment for plaque development and retention.

The results of a study by Iyer (1962), showed that the orthodontic appliance used did not seem to be responsible for poor gingival response because the factors of poor oral hygiene and existing gum condition might have contributed to it.

Cohen (1964), also supported the view that the combination of gingival irritation from appliances and lack of oral hygiene may be

responsible for the pronounced inflammatory gingival changes. He stressed the importance of supervised oral hygiene measures during orthodontic therapy to reduce the gingivitis and gingival enlargement to a minimum.

Hoover (1967), a periodontist, lent his support to theories of multiple causes of gingival and periodontal disease associated with orthodontic treatment, the central causal factor concerning the accumulation of materia alba and plaque.

These early observations of iatrogenic damage to the gingiva from orthodontic appliances, lacked objectively based supporting evidence in the form of controlled clinical testing.

(B) RECENT CLINICAL EVIDENCE - GINGIVAL CHANGES WITH
FIXED ORTHODONTIC THERAPY

Balenseifen and Modonia (1970), collected and studied plaque samples from orthodontic patients before and after placement of orthodontic bands and arch wires. The experiments showed that the presence of orthodontic appliances in the mouths of patients stimulates an environmental change, representing an increase in both plaque area and concentration. The plaque changes following placement of orthodontic bands and arch wires are the result of inherent irregularities of fixed orthodontic appliances. The authors believe that the appliances provide additional surface for the collection and retention of food and debris, and also protect the plaque from the actions of brushing, mastication and salivary flow. This study lacked an untreated control group. Also the authors did not supervise the important variable of oral hygiene, and so one may question whether a supervised program of plaque removal would have resulted in similar environmental changes.

Zachrisson and Zachrisson (1972a), conducted a longitudinal study on the gingival conditions of 49 patients aged eleven to thirteen years, treated with fixed orthodontic appliances by an edgewise light-wire technique. A non-treatment control group, consisting of individuals of similar age was included for the purpose of comparing the plaque accumulation and gingival condition. Repeated motivation and instruction in toothbrushing with a horizontal scrub technique was given, and emphasis was directed toward the gingival areas.

Assessments of oral hygiene were performed according to the criteria of the Plaque Index System (Silness and Løe 1964). Gingival condition was assessed according to the criteria of the Gingival Index

System (Loë and Silness 1963). Regular assessments were made in all patients at the start, two to five times during the period of active treatment, and at the removal of the appliances.

The results demonstrated that in spite of good oral hygiene with low plaque scores, the majority of patients developed generalized moderate gingivitis within one or two months after the placement of the appliances. Once established, however, the gingival changes did not vary considerably during the further course of treatment. (These findings substantiate the findings of earlier investigators). (Skillen, 1940; Kobayashi and Ash, 1964; Huettner, 1969).

Even those patients with perfect tooth cleansing showed evidence of mild inflammatory gingival changes during treatment. However, severe inflammation was not observed as frequently as reported by others (Spence, 1955), and this may be explained by the regular recording and supervision of the oral hygiene status. (Lindhe and Koch, 1967).

The gingival reactions of orthodontic patients receiving repeated motivation and instruction in oral hygiene are shown schematically. Fig. (1)

The Gingival Index scores were consistently higher at the interproximal surfaces than at the buccal areas; and this finding is in accordance with previous observations. (Baer and Coccaro, 1964). The appliances had most adverse influence in the posterior regions. Bands cemented on the central parts of teeth in anterior regions tended to influence the gingival condition little, particularly buccally. This distribution corroborates the earlier observations of Skillen and Krivanek (1938), and Huettner (1969), which Zachrisson and Zachrisson (1972a, 1972b) attributed to the increased retention abilities introduced

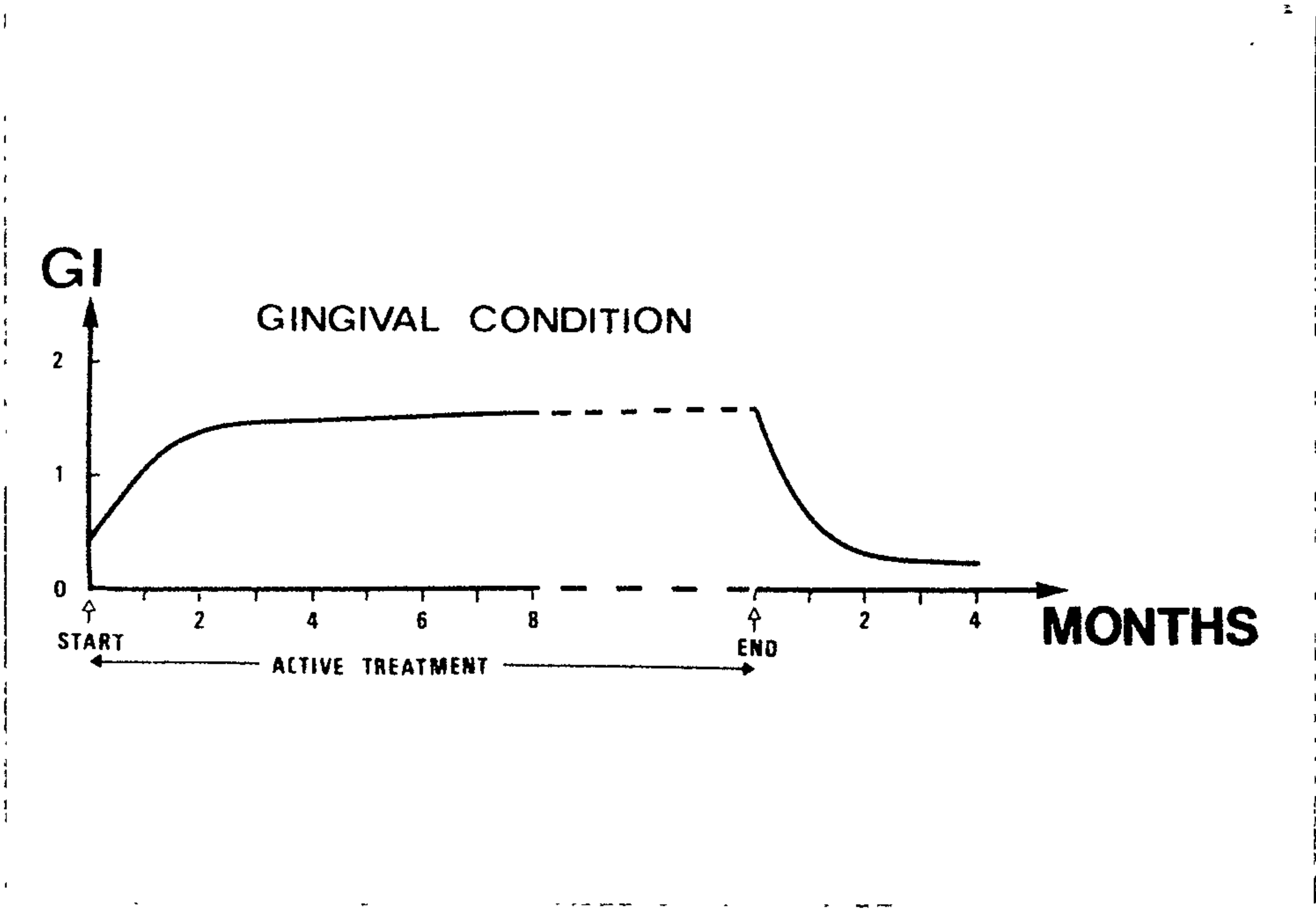


FIG. 1. Gingival reactions associated with fixed orthodontic therapy and regular toothbrush instruction.
(from Zachrisson, 1976)

along the gingival margin and mechanical irritation of the band material. With regard to individual teeth investigated, the first molars were generally the most affected; and the central incisors the least. The general tendency to develop gingivitis in the age group is known to be large (Lindhe and Koch, 1967; Parfitt, 1957). Even though zero levels of gingival index were not approached, the Zachrisson study showed that inflammatory changes during the period of active therapy rapidly decline with the removal of appliances, as suggested by Spence (1955) and Hoover (1967).

The results of a similar longitudinal study conducted by Zachrisson and Zachrisson (1972b), confirmed the authors' previous findings.

Klaehn and Pfeifer (1974), examined the relationship of orthodontic treatment and plaque to periodontal disease. Fifty patients, eleven to seventeen years of age, with maxillary and mandibular fixed edgewise appliances were examined at three-monthly intervals during the course of treatment. Routine home care instructions were given to all patients. The results showed that gingival hyperplasia in varying amounts occurred in most patients. Measures of periodontal disease showed that the periodontal index of Russell (1956) increased as treatment progressed. In the case of oral debris, as soon as appliances were placed, the percentage of patients with a low or average oral debris index (Greene and Vermillion, 1960), increased.

In considering the distributional pattern of gingival hyperplasia, a four-to-one ratio was found to exist between the amount occurring around the posterior teeth and the amount occurring around the anterior teeth respectively. This greater incidence around the posterior teeth was also found by Zachrisson and Zachrisson (1972a, 1972b). A similar four-to-one ratio of gingival hyperplasia was found to exist between the amount occurring interproximally and the amount occurring at the middle

of the crown. The authors claimed that difficulty in brushing the posterior teeth and the interproximal areas was an important factor.

The authors found that, as long as bands are placed on teeth, they will result in gingival irritation, which can be minimised by proper fitting. Even those patients who maintained excellent oral hygiene could not escape the irritation caused by the appliances themselves. Therefore, some gingival inflammation is inevitable when orthodontic appliances are placed on teeth. They also claim that interproximal hygiene can be improved by more thorough toothbrushing. The results of this study concur with the findings of Zachrisson and Zachrisson (1972a and 1972b).

In the above study inflammatory and hyperplastic changes in the gingiva which occurred during treatment were, as found by Spence (1955), Hoover (1967) and Zachrisson and Zachrisson (1972a and 1972b), reversible upon appliance removal. Also, a direct relationship between oral hygiene and periodontal disease was established, supporting the findings of Lovdal, Arno and Waerhaug, (1958); Russell and Ayers, (1960); Greene, (1960 and 1963); Ramfjord, (1961); O'Leary, Shannon and Prigmore, (1962); Ash, Gitlan and Smith, (1964); Sheiham, (1969) and Suomi, (1971).

Lampert and Unterer (1977) treated a group of 30 patients aged from eleven to fifteen years with either fixed appliances, or removable plates, or by functional orthodontics. Prior to the beginning of treatment, and one week and six weeks thereafter, Oral Hygiene Index (O.H.I.) was recorded. In agreement with previous investigations as reported in the study by Zachrisson and Zachrisson (1972a), the inflammatory symptoms of the gingiva were shown to be a function of the O.H.I.

However, the O.H.I. grew worse during orthodontic treatment, especially in the group with fixed appliances. This finding is most likely related to the absence of any oral hygiene regimens during the study; as compared to the findings of Zachrisson and Zachrisson (1972a, 1972b), where lower plaque scores were established with regular oral hygiene instruction.

(C) PLAQUE AS THE SOURCE OF THE GINGIVAL IRRITANT. J

Studies by Ellison (1970), Socransky (1970), Kelstrup and Theilade (1974) have suggested that micro-organisms play a primary role in the aetiology of most forms of human periodontal disease; but are specific organisms responsible for specific disease forms, as suggested by Socransky (1977)?

Bacterial plaque has been suggested as a causative irritating agent of gingival inflammation (Brandtzaeg, 1966; Arnim et al., 1959 and 1961). In experimental gingivitis (Løe, Theilade and Jensen, 1965), there is an increase in the total mass of plaque, which is accompanied by an increase in proportions of the genus *Actinomyces*. This group of gram-positive organisms tends to be the dominant genus associated with supragingival plaque (Socransky, 1977).

Page and Schroder (1976) suggested that gingivitis may be a response to the accumulation of micro-organisms but were uncertain as to the mechanism by which gingivitis switched to destructive disease. Two hypotheses were suggested. In the first, an activation of host immuno-pathologic processes would exacerbate the disease and lead to destruction of the tissues. In the second, an alteration of the local bacterial component, either by local over-growth or addition of a pathogenic new species would initiate tissue destructive processes. Existing data support the second hypothesis.

Immunologic studies of periodontal disease constitute a major area of dental research. Present information suggests that immunology or host responses play some role in gingivitis (Nisengard, 1977). If host immunity provides protection or contributes to the pathology of gingivitis, bacterial antigens must gain access to the gingiva to first sensitize

the host and then provoke an immune response. Page and Schroder (1976), suggested the regular penetration of bacteria and their antigens into the gingival tissues. The histopathology of gingivitis is consistent with an immunologic response.

Host factors which play a role in modifying, preventing or controlling periodontal disease, include physical, biochemical, immunologic activities and non-immunologic host responses. Studies by Brill and Brönnestam, (1960); Shilltoe and Lehner, (1972); Attstrom, Laurel, Larsson and Sjöholm, (1975) have suggested that some of these could be effective in the gingiva and some could be effective within the tissue.

Nisengard (1977) stated that a number of host responses play a protective role against plaque. At the same time, other host responses contribute to the pathology of gingivitis. Whether these responses are more important in the pathogenesis than the direct effects of the bacteria is unknown.

Socransky (1977), indicated that it would be imperative to determine which micro-organisms are involved in the aggressive breakdown of periodontal supporting structures and to distinguish clearly between such organisms, organisms which initiate gingivitis, and organisms which are compatible with the host.

Gingivitis is a complex multi-factorial disease. Nisengard (1977) feels that the lesion is most likely the net response of multiple factors, both bacterial and host factors.

(D) ANIMAL EXPERIMENTATION - GINGIVAL CHANGES FROM
ORTHODONTIC TREATMENT

As early as 1906, Sandstedt, experimenting upon dogs, reported his findings of general tissue changes. These changes included the gingiva and resulted from orthodontic tooth movement. His findings were later confirmed by the work of Oppenheim, (1942), Gottlieb, (1927); Schwartz, (1932) and Orban, (1947).

Skillen and Krivanek (1938), undertook a series of experiments to see what effects a well-adjusted orthodontic appliance might have on the gingiva of dogs over a relatively short space of time. In general, all appliances caused more or less irritation within 24 hours. Clinically, a slight inflammation was always in evidence. The degree of gingival involvement appeared to depend upon the length of time the appliances were in position, and upon the accumulation of debris about the appliance.

In these early experiments on animals the variable of oral hygiene was not controlled. More recent experiments on dogs by Lindhe, Hamp and Löe (1973 and 1975), and Svanberg, Lindhe, Hugoson, and Gröndahl (1973), have demonstrated the important role played by the microbial plaque in the aetiology of gingivitis.

The investigation by Lindhe, Hamp and Löe (1975), demonstrated that it is possible in dogs to establish and maintain a normal gingiva by subjecting the animals to daily repeated and carefully performed tooth cleansings. However, one may question whether similar findings would have resulted if orthodontic appliances had been used under the same conditions.

(E) GINGIVAL CHANGES AS A RESULT OF ORTHODONTIC TREATMENT
- TEMPORARY OR PERMANENT SITUATION?

There is some evidence that the movement of teeth with orthodontic appliances can cause gingivitis (Skillen, 1940; Spence, 1955). According to James and Beagrie (1963), this may be a transient condition, but where there is a susceptibility to gingival inflammation and this is aggravated by orthodontic appliances, the resultant hyperplastic gingivitis may not resolve.

James et al (1963) examined patients who had received orthodontic therapy some years previously. The supporting tissues of some patients showed chronic gingivitis associated with poor oral hygiene. The authors do not suggest that orthodontic treatment causes chronic gingivitis. They do suggest, however, that before starting orthodontic treatment more attention should be paid to assessing the health of the periodontium and improvement in the standard of oral hygiene where indicated.

Hoover (1967) and Schluger (1968) stated that hyperplastic gingivitis is probably the most common periodontal problem associated with orthodontic therapy. They claimed, in fact, that this condition is so prevalent it is regarded as a transitory condition and accepted by the majority of orthodontists as being a normal by-product of their therapy. However, as shown by James et al. (1963), the gingiva does not always return to normal at the completion of treatment.

Results of two separate longitudinal studies by Zachrisson and Zachrisson (1972a, 1972b) on gingival conditions associated with orthodontic therapy, showed that inflammatory changes during the period of active therapy rapidly declined with the removal of appliances; and no permanent damage to the periodontal tissues could be demonstrated.

2. EVALUATION

(A) INDICES FOR THE MEASUREMENT OF PLAQUE AND GINGIVAL INFLAMMATION

i) Definition

According to Davies (1968), indices of periodontal disease are measurements which express numerically the status of a group of teeth with respect to the disease. They can be used to measure prevalence or incidence. They can also be used to measure the severity of a disease, ranging from its absence to its terminal stages.

ii) Requirements of an Index

In the case of most diseases it suffices to assess their presence or absence; in the case of periodontal disease this is highly inadequate. The variability in severity of periodontal disease may also be indicated by counting the number of inflamed periodontal units or by arbitrary descriptive terms such as mild, moderate or severe. However, to evaluate the severity of periodontal disease more precise indicators are desirable.

Davies (1968) and Massler, Schour and Chopra (1950) suggested requirements for indices; and these were summarised by Hazen (1974):-

- i) it should be simple to use and should permit the study of a large number of persons in a minimum time and at minimum cost.
- ii) the criteria should be clear and readily understandable to promote diagnostic reproducibility both within and between examiners.
- iii) it should be amenable to statistical analysis.
- iv) if it is used to describe severity, the index should be equally sensitive throughout the scale and should indicate in a meaningful way the clinical stages in the disease process.

iii) Indices for Assessing Gingival Inflammation

A number of indices to measure and classify gingival inflammation have been proposed. These indices for assessing the state of inflammation are based on the parameters of changes in colour and form, loss of stippling and bleeding tendency. However, there is a general lack of agreement as to the order of occurrence of the different parameters in the development of gingivitis. These have been extensively reviewed and discussed (Hazen, 1974).

The best known indices are:-

1. The Gingival Index, L  e and Silness (1963).
2. The Sulcus Bleeding Index, M  hlemann and Mazar (1958).
3. The P.M.A. Index, Schour and Massler (1949).
4. D.H.C. Index of Smith, Suomi, Greene and Barbano (1970).
5. The Periodontal Index of Russell (1956).
6. The Periodontal Disease Index, Ramfjord (1959).

The main purpose of creating the Gingival Index System (L  e and Silness, 1963), was to introduce a system for the assessment of the gingival condition which clearly distinguished between the quality of the gingiva (severity) and the location (quantity) as related to the four areas (buccal, mesial, lingual and distal) which make up the total circumference of the marginal gingiva.

At the time the Gingival Index (G.I.) was taken into use, the existing index systems, the P.M.A. Index (Schour and Massler), the Periodontal Index (Russell) and the Periodontal Disease Index (Ramfjord) did not fulfil this requirement.

The Gingival Index, unlike Russell's Periodontal Index (1956), does not consider periodontal pocket depth, degrees of bone loss or any

other quantitative changes of the periodontium. The criteria are entirely confined to the qualitative changes in the gingival soft tissue. This system will be further reviewed in the Method Section of this thesis.

Criteria of Gingival Inflammation

Among the authors of the various indices there is disagreement as to the order of occurrence of the various parameters of inflammation in the progression of gingivitis. Løe and Silness (1963) in their Gingival Index record a slight change in colour as the earliest sign of gingival inflammation, and bleeding comes at a later stage. The Sulcus Bleeding Index of Mühlemann and Mazor (1958) records the presence of bleeding from the gingival sulcus upon gentle probing as the first sign of gingival inflammation.

Løe (1974) feels that his index detects an earlier stage of gingivitis than the Sulcus Bleeding Index. Waerhaug (1974) suggests that in the discussion of what comes first, the bleeding or the colour change, it depends upon where the sulcus is probed. Buccally or lingually the colour change comes first and inter-proximally bleeding is first. The Løe approach would appear to be the most critical and most valid at this time (Hazen, 1974).

iv) Indices for Assessing Plaque

Research on the epidemiology of periodontal disease has demonstrated a close correlation between gingival disease and oral debris (Lovdal, Arno and Waerhaug, 1958; Greene, 1960 and 1963; Schei, Waerhaug, Lovdal and Arno 1959). There is substantial amount of evidence that

bacterial plaque is the most common direct cause of gingival disease (W.H.O. 1962). Therefore, any study with the aim of broadening the understanding of gingival disease should include an assessment of the oral hygiene status. (Silness and Løe, 1964).

Plaque may be assessed by three methods:-

- (a) plaque area
- (b) plaque thickness
- (c) plaque weight.

(a) Plaque Area Measurements

The area of tooth surface covered by plaque is measured.

Indices which do this are:

1. The Periodontal Disease Index, (Ramfjord, 1956)
2. The Oral Hygiene Index, (Greene and Vermillion, 1960)
3. The Oral Hygiene Index - Simplified, (Greene and Vermillion, 1964)
4. The Kupczak, Volpe and King Scoring System (1969)
5. The Quigley and Hein system (1962).

Of total area measurements, Mandel (1974) claims that the limited evidence available indicates that such techniques as indicated by disclosing solutions are subject to substantial error. Whether the errors are greater than those of a numerical index has not yet been determined. Mandel (1974) concludes that in view of the paucity of accuracy and reproducibility, total area measurements would appear to have limited application to clinical studies involving any appreciable number of subjects.

(b) Plaque Thickness

The Plaque Index System was introduced by Silness and Løe (1964) and described more fully by Løe (1967). It is the only Index that considers plaque thickness in scoring. It is fundamentally based on the same principle as the Gingival Index (Løe and Silness, 1963 and Løe, 1967); namely, the desirability of distinguishing clearly between the severity and the location of the soft debris aggregates and mineralized deposits. The purpose of introducing this system was also to create a plaque index which would match the Gingival Index completely.

The Plaque Index scores consider only differences as to thickness of the soft deposit in the gingival area of the tooth surfaces, and no attention is paid to the coronal extension of the plaque. This system will also be further reviewed in the Method Section of this thesis.

One of the difficulties encountered using the Silness-Løe index is the scoring of the interdental areas. The tendency is to score them from the facial aspect and assign a single score to the lingual area. Ainamo (1970) overcame this by examining the interdental spaces from both lingual and facial aspects and assigning the greater index value to the mesial or distal surface.

Two studies lend support to the validity and reliability of the Plaque Index. Lang, Østergaard and Løe (1972), found an almost linear correlation between the index as used on the facial surfaces of anterior teeth and the total area of plaque as measured photographically (planimetry of enlarged projections). When very small amounts of plaque were measured, the index was more consistent than the photographic

technique. The observations of Loesche and Green (1972) indicate that unstained plaque scores correlate better with gingivitis and plaque weight than stained scores and, hence, the convenience of disclosing may be at the expense of accuracy when the index is to be related to gingivitis.

There is no data available upon the reproducibility of this index. However, if the same examiner conducts the clinical trial on the same group of patients, standardization should not be too difficult. (Mandel, 1974).

(c) Plaque Weight

Plaque can also be assessed by removing it from the tooth surface and having it weighed. The standardised foil technique (Marthaler, Schroeder and Mühleman, 1961) and direct harvesting of plaque (Caldwell, Mann, Finn and Formicola, 1971) are two suggested methods. Both of these methods are precise procedures, but have rather limited clinical applicability because they are time-consuming if large numbers of tooth surfaces are being used. Thus the technique does not lend itself to daily use.

Plaque may be assessed as wet weight or dry weight. Loesche and Greene (1972) found wet weight easier to obtain than dry weight, correlated closely with dry weight, and showed a higher correlation with gingivitis than did dry weight.

v) Partial Mouth Scoring

There are diverse opinions on partial mouth scoring (Alexander, 1970). For assessment of oral hygiene the teeth examined vary from total

mouth (PMA Index, 1947), to six selected teeth (Ramfjord, 1956; Greene and Vermillion, 1960; Shick and Ash, 1961; Løe and Silness, 1963; and Silness and Løe, 1964), to anterior teeth only (Quigley and Hein, 1962).

The prototype procedure for the use of partial mouth scoring of plaque assessment was introduced by Ramfjord (1956) for use with his Periodontal Disease Index. He scored:-

The maxillary right first molar

The maxillary left central incisor

The maxillary left first bicuspid

The mandibular left first molar

The mandibular right central incisor

The mandibular right first bicuspid.

This scoring technique was modified by Shick and Ash (1961), who examined only the facial and lingual surfaces of six selected teeth.

The use of a six-tooth index has been shown by Shick and Ash (1961), and by Jamison (1968) to be a valid representation of plaque scores for the whole mouth. It was suggested by Kupczak, Volpe and King (1969), that a numerical plaque scoring technique could be used on a partial mouth basis with a high level of correlation with total mouth scores.

Hazen (1974) feels that partial mouth scoring is excellent for surveys but has reservations regarding its use in therapy studies. Mandel (1974) feels that for plaque, scoring of all surfaces of all teeth is the ideal. However, partial mouth scoring is adequate provided the anterior and posterior teeth are examined and all surfaces are considered. The six-tooth systems of Ramfjord (Periodontal Disease Index, 1956), Greene and Vermillion (Simplified Oral Hygiene Index, 1964), Løe and Silness (Gingival Index, 1963) and Silness and Løe

(Plaque Index System, 1964) which examine all the surfaces of four posterior and two anterior teeth, satisfy these requirements.

Alexander (1970) found that the results of examination of the gingival condition restricted to the six Ramfjord teeth would not have differed significantly from results obtained for all teeth in the mouths of the groups examined.

Mills, Thompson and Beagrie (1975) used eight methods of partial mouth recording to determine which were the most representative of the entire dentition for plaque and periodontal disease. The results obtained from full mouth and partial mouth scoring for the same individual were compared. The results were valid irrespective of the type of partial mouth recording used. Plaque and periodontal scores for the anterior segment of the mouth gave very similar values to total mouth scoring.

For the present investigation the author has favoured the use of the matching Gingival Index (Loë and Silness, 1963) and Plaque Index (Silness and Löe, 1964). These indices satisfy the requirements of this study, where emphasis is placed on the gingival third of the tooth, the region where most orthodontic patients have greatest difficulty in maintaining satisfactory oral hygiene standards.

(B) EXAMINER VARIABILITY.

According to Clemmer and Barbano (1974), "when evaluating the results of periodontal clinical trials it is desirable to have some information on the reliability of the scores and indices used. In particular, there is interest in whether the examiner scores the same condition in the same way every time it is observed, and whether different examiners score the same condition in the same way. The goal is to reduce the between and within examiner variability as much as possible, so that, hopefully, it will have little effect on inferences about treatment and time differences."

A major problem confronting examiners in the diagnosis of gingivitis is their ability to be consistent, especially where qualitative terms such as "slight", "moderate" and "severe" are involved.

Crowley (1955) in a study investigating the consistency of qualitative ratings reported that, following a training period, examiners were able to duplicate their own scores 79 per cent of the time, and show agreement between themselves 52 per cent of the time.

Davies, Kruger and Homan (1967), found that inexperienced examiners have great difficulty and are most unreliable in duplicating periodontal disease scores, especially gingivitis scores.

Mandel (1974), feels that for successful use of indices with minimum intra-and inter-examiner variation, clearly defined descriptions of the criteria must be available and the examiners must be adequately trained.

Smith, Suomi, Greene and Barbano (1970) indicated from the

results of their study that standardization sessions are valuable as a method of reducing intra-examiner variation in scoring gingival disease status.

The P.M.A. Index and the Gingival Index System are two major indices in current use for measuring gingivitis clinically. The P.M.A. Index has been criticised because of the poor inter-examiner agreement and it has been claimed that the P.M.A. score bears no direct relationship to the severity of the gingivitis (Sandler, 1952; Parfitt, 1957; Ramfjord, 1959; Hutchinson, 1958; Alexander, 1970). Gjermo (1974) believes that the problem of calibration is greater with the P.M.A. Index than with other indices.

An investigation was conducted by Alexander, Leon, Ribbons and Morganstein (1971) into the intra- and inter-examiner reliability achieved by three inexperienced examiners using the P.M.A. and Gingival Indices. Four programmes of progressively intensive training in the use of each index were utilized.

Intra-examiner agreement was obtained with each method after only a relatively short and modest programme of training. Inter-examiner agreement was only achieved with each index after a prolonged and intensive training programme which included clinical instruction by an experienced examiner.

The results of this investigation indicate that an intensive and prolonged training programme would be the best approach to training examiners. A high degree of correlation was found between the P.M.A. and Gingival Indices suggesting that the two different methods of assessing the severity of inflammation produces similar results and

similar inter- and intra-examiner agreement. The Gingival Index has the distinct advantage of clear and concise mandatory instructions having been laid down for its use. There is considerable variation in the use of the P.M.A. Index because of lack of such instructions.

C. EPIDEMIOLOGY

Epidemiology is the field of science that deals with factors and conditions which influence the frequency and distributions of health, disease and mortality. From research in epidemiology, information has been deduced concerning the distribution of gingival disease in relation to many factors such as sex, age, social and dietary conditions, hygiene and habits. (Löe, 1963).

Early studies in the prevalence of gingivitis in children were conducted by Black, (1915); Ainsworth and Young, (1925); McCall, (1933); Messner, Gafafer, Cady and Dean, (1938); King, (1945), and Brucker, (1943). The variation in prevalence of gingivitis in children in these early studies was considerable - from 3.5 per cent (Messner et al.) to over 90 per cent (King). This variation is attributed to lack of uniform indexing. However, it was shown that incidence increased with age and was higher in boys than in girls.

James (1963) conducted a longitudinal study on the gingival conditions of 1,433 children, from two to sixteen years of age living in an Institution. Results of the study showed:-

1. Incidence and Distribution of Gingivitis

The percentage of children with gingivitis increased significantly with increasing age. Prevalence was found to be low in young children with their complete deciduous dentition. Between the ages of six to seven years there was a sharp increase in both sexes. Thereafter, it plateaued but remained high, up to the age of fourteen years. This increase was found not only in the number of children affected, but also in the severity of gingivitis. This increase in both prevalence and severity of gingivitis after

the age of six years has also been reported in previous studies. (Day, 1940; King, 1945; Day and Shourie, 1947 and 1950; Schour and Massler, 1950; Massler, Schour and Chopra, 1950 and Parfitt 1957).

2. Sex Differences -

In earlier studies by Day and Shourie (1947 and 1950) males showed a significantly higher incidence of gingivitis than females, reaching a peak at puberty.

In James' study, while there were significant differences between the gingivitis experience in boys and in girls, such differences were not very consistent. In the age group from six to eight years, girls in general showed a higher percentage affected by gingivitis than did boys. It was felt that the eruption of incisor teeth accounted for this sharp rise in gingivitis. Girls experience more gingivitis over this period than boys of the same age, because of their earlier tooth eruption. This explanation was also offered by Massler, Schour and Chopra (1950).

The rise in the prevalence of gingivitis continued until the age of eight, in a parallel fashion, with girls still showing more gingivitis than boys. After the age of eight years the girls improved a little; boys continued to rise until nine years, when they too showed a slight improvement.

The prevalence of gingivitis starts to rise again after the age of ten years in girls and boys. At eleven years the girls reach their prevalence peak and then improve dramatically. Boys reach their prevalence peak at thirteen years. However, their improvement after this is not as significant as amongst the girls. The severity of gingivitis reflects a pattern similar to that of prevalence. This sex

difference in both prevalence and severity of gingivitis has been reported by other investigators. (Day and Shourie, 1947 and 1950; Massler, Schour and Chopra, 1950; Parfitt, 1957).

A number of suggestions have been proposed for this sex difference in prevalence and severity of gingivitis around the age of puberty:-

1. King (1945) claims that, as the greatest incidence of gingivitis in boys and girls occurs at approximately the same time as the onset of puberty, a hormone factor may be responsible.
2. Massler, Schour and Chopra (1950) suggested that this difference might be explained on the basis of better oral hygiene in girls. Girls tend to become more conscious of cleanliness as they approach puberty than do boys.
3. Day (1951), feels the generally high incidence of gingival disease around the age of puberty may be related to hormonal factors, and the consistent fall in prevalence after the age of fourteen may be explained in part on social grounds related to improvement in oral hygiene.

Epidemiologic studies have shown a high prevalence of gingivitis in children between the ages of nine and fifteen. (Massler, Schour and Chopra, 1950; Day, 1951; Parfitt, 1957; James, 1963; James, Jackson, Slack and Lawton, 1960). According to Baer and Coccaro (1964), this tendency for gingival inflammation to occur in the same age group in which orthodontic therapy is being rendered, could explain the large number of gingival hyperplasias seen in patients under orthodontic treatment. Baer and Coccaro observed a gingival enlargement particularly of the papillary area, to occur about teeth which are banded

for orthodontic purposes. The authors noted that many patients have little or no gingival tissue reaction to orthodontic banding; whilst some show a high degree of tissue response, often severe enough to cause the gingival tissue to literally "grow" over the bands.

The authors found that this marked bulbous enlargement of the interproximal papillae seen in orthodontic patients is identical, clinically, to that seen in any adolescent with local irritational factors, whether it be poor oral hygiene, mouth breathing, or the presence of calculus or debris. In fact, some gingival enlargement of the anterior segment of the mouth is so common in the prepubertal and premenarchial period that it has been referred to by Cohen (1964) together with the appearance of secondary sex characteristics, "an additional sign of the beginning of prepubescence".

Epidemiologic studies (Schour and Massler, 1947; Massler, Schour and Chopra, 1950; Day and Schour, 1950; Ainsworth and Young, 1925; Day, 1951; Parfitt, 1957; James, 1963) have shown that the prevalence of gingival inflammation reaches a peak between the ages of eleven and thirteen and then starts to decline somewhat, to the age of about seventeen years. Baer and Cocco (1964) list a combination of factors which might explain the improvement in the periodontal condition of these patients following the removal of the orthodontic appliances:

- i) The local irritation from the orthodontic bands has been removed;
- ii) an obstacle in the way of performing good oral hygiene has been removed; and
- iii) there is now an inherent tendency, in the age group in which orthodontic therapy is most often terminated, for gingival inflammation to subside.

D. PHOTOGRAPHY

Colour photographs of the teeth and gingiva taken at the time of clinical examination increase the accuracy and reliability of the information recorded, and are essential evidence of the evaluation of toothbrushing and the effects of toothbrushing. (Massler et al., 1957). Several investigations have been conducted to evaluate the effects of toothbrushing on the cleanliness of the enamel and the inflammation of the gingivae with the use of colour photographs.

In the study by Massler et al. (1957), the effects of tooth brushing on the cleanliness of the enamel and the inflammation of the gingivae were studied by means of clinical evaluation and standardized colour photographs taken at zero, ten and fifteen weeks. The analysis was quantified by rating the cleanliness of the enamel, by assessing the amount of gingivitis according to the criteria of the P.M.A. Index, and by the colour photograph.

The results of this study showed that when the P.M.A. Index is used as a supplement to the colour photographs, an accurate quantitative evaluation of changes on tooth cleanliness and in gingival inflammation can be made.

The authors were in agreement with Van Huysen and Boyd (1952), that such records are essential for accurate and objective evaluation of the effects of toothbrushing on the enamel and gingivae.

In a study by James (1963), one hundred subjects were examined and their anterior gingival conditions were classified as "good, fair, or poor". A standardized photograph was taken of this anterior region. Six months later the slides were reassessed on the basis of their photographic appearance. Three months later the series was again

assessed twice, with a short interval between the two examinations. The results showed a close agreement between the scores of the photographic assessments; and all were slightly lower than those obtained from the clinical examination.

James stated that the taking of a standardized photograph and subsequent assessment of the projected transparency is a better method than a clinical diagnosis of the subject taken at the time of the original examination.

The author claims that there are several obvious advantages:-

- i) The photographs are always there for re-appraisal.
 - ii) They are a permanent reminder of the standards adopted at the time of the assessment. The advantage of being able to refer constantly to the baseline condition protects examiners against all the current difficulties of applying criteria to conditions that, by their very nature, have no finite limits.
 - iii) A whole series can be assessed within a short period, whereas actual examinations of subjects might have to be spread over many months, or even years, with the risk of shifting diagnostic standards.
 - iv) Most importantly, photographs can be randomised and assessed blind, thus eliminating the possibility of unconscious bias.
- This 'blindness' would be of great importance in a clinical trial.

A study by Lees (1974), was undertaken to assess the value of reasonably standardized colour photography in clinical assessment of gingivitis. Intra-oral colour photographs were taken during a survey of 140 school children to test the consistency of colour transparencies in recording gingival status.

All subjects were examined clinically and then photographed. The oral hygiene and gingival status were assessed for plaque accumulation and gingival inflammation using the severity scale suggested by Ramfjord. (1959).

When the indices derived from the photographic study were compared with those from the clinical study it was found that 73.1 per cent matched, while 19.2 per cent of the photographic readings were higher and 7.7 per cent were lower. The results of this study are in accordance with those obtained by James (1963) and the views regarding the advantages of colour photographs are also shared. However, Davies, Kruger and Homan (1967), were unable to obtain uniformity and reproducibility in the assessment of periodontal disease.

3. DIRECT-BONDED ORTHODONTIC APPLIANCES AS RELATED TO GINGIVITIS

It has been suggested that one of the advantages of direct-bonding is improved gingival health. One of the iatrogenic effects which can be associated with orthodontic treatment is gingival inflammation. Direct-bonded brackets offer a potential solution to this treatment problem. (Zachrisson, 1978).

Retief and Sadowsky (1975), reported on the clinical results obtained on a cross-section of patients treated with a direct-bonding system used in conjunction with the acid-etch technique. They found that one of the advantages of "bandless" orthodontics was that gingival irritation is decreased because the bonded attachments do not impinge on the gingival margins.

Reynolds (1975), also listed the advantages of direct-bonding, and included the decreased soft tissue irritation and the improved oral hygiene at the gingival margin. Similar advantages were also reported by Brandt, Servoss and Wolfson (1975).

Garn (1976), conducted a seven months clinical study to evaluate a commercially available direct-bonding system during orthodontic treatment procedures. Empirical evaluation of gingival inflammation in direct-bonded patients revealed that inflammation was dependent on oral hygiene co-operation, the presence of direct-bond brackets notwithstanding. However, direct-bond brackets posteriorly did eliminate the gingival irritation found with band edges placed subgingivally.

Improved gingival health is generally one of the claimed advantages of direct-bonding. However, according to Zachrisson (1978) this is not necessarily true. His findings strongly emphasised that

whenever bracket bases were over-extended in size, or excess sealant or adhesive was used, the gingiva could be even worse than when bands were used, irrespective of the oral hygiene situation. On the other hand, when bases were small, little adhesive was used, and oral hygiene co-operation was good, the gingiva could be maintained normal throughout treatment. Such excellent gingival conditions were never registered in his full-banded patients.

Zachrisson and Brobakken (1978), conducted a longitudinal clinical trial in 42 children to compare some commonly used techniques for orthodontic bracket bonding. The purpose of the study was to make a blind comparison of some of the most commonly used products. Thus, metal brackets with either mesh-backed or perforated bases were bonded directly or indirectly with three adhesive types with small or large filler particles. Of particular interest for the study was the degree of plaque accumulation along the brackets and the gingival margins, and the reaction of the gingival tissues.

Assessments were made according to the criteria of the Plaque and Gingival Index Systems, at each monthly visit during a test period of six months.

Assessments of the plaque situation around the brackets and along the gingival margins and the gingival condition revealed that:-

1. The bonding adhesive with small filler particles was significantly more hygienic than one with large, coarse filler particles with regard to plaque accumulation along both the brackets and the gingival margin, and it induced less gingival inflammation.

whenever bracket bases were over-extended in size, or excess sealant or adhesive was used, the gingiva could be even worse than when bands were used, irrespective of the oral hygiene situation. On the other hand, when bases were small, little adhesive was used, and oral hygiene co-operation was good, the gingiva could be maintained normal throughout treatment. Such excellent gingival conditions were never registered in his full-banded patients.

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1. The bonding adhesive with small filler particles was significantly more hygienic than one with large, coarse filler particles with regard to plaque accumulation along both the brackets and the gingival margin, and it induced less gingival inflammation.

2. When direct and indirect bonding techniques were compared, the differences in plaque retention and gingival condition were not statistically significant for the adhesive with small filler particles.
3. The mesh-backed brackets retained less plaque than the brackets with perforated pads.

The issue of the use of direct-bonded orthodontic attachments in relation to gingival inflammation and plaque accumulation is still to be resolved. However, the use of smaller brackets with minimal adhesive appears to offer a potential solution towards improving gingival health and oral hygiene status.

4. RELATIONSHIP BETWEEN ORAL HYGIENE AND GINGIVITIS UNDER SUPERVISED AND PERMISSIVE PROGRAMMES

A committee of the 1966 World Workshop on Periodontal Disease (Ramfjord, Kerr and Ash, 1966) concluded that:-

- i) there is a very strong relation between periodontal disease states and mouth cleanliness, individual by individual;
- ii) clinical trials have demonstrated that progress of periodontal disease can be retarded or halted by good personal hygiene coupled with adequate scaling.

To illustrate the first point, Greene (1963), conducted a study to test this relationship. He confirmed that for each age group studied the relationship is the same; that is, as the oral hygiene scores increase, periodontal scores also increase.

To illustrate the second point, studies by Lovdal et al. (1961), Brändtzaeg (1964), and Löe, Theilade and Jenson (1965) showed the positive effects of good oral hygiene practices on gingival condition.

The effect of toothbrushing on gingivitis was evaluated statistically by McDonnell and Domalakes (1952) in 589 boys aged ten to eighteen years. These boys were carefully subjected to an intensive and stringently supervised programme of toothbrushing for a period of nine months. Gingivitis was assessed throughout the programme by the P.M.A. Index. The authors demonstrated a marked decrease in the amount of gingivitis after this intensive programme, but stressed the fact that this group had an unusually high incidence of gingivitis initially, and that the toothbrushing regime was very carefully supervised.

Massler, Rosenberg, Carter and Schour (1957), conducted a study to observe the effects of a permissive, non-supervised programme of toothbrushing on gingival inflammation and tooth cleanliness in a group of 154 Naval inductees aged 17 to 22 years. Each subject was given a toothbrush and instructed to brush his teeth on arising and after each meal. The brushing was neither supervised nor checked in any fashion; that is, it was not controlled. Evaluation of oral hygiene from standardized colour photographs showed in most cases, no significant decrease in the amount of stain or soft debris after fifteen weeks of toothbrushing. Assessments of gingival health using the P.M.A. Index, after fifteen weeks of permissive toothbrushing showed no changes in the majority of cases. The study indicates that a permissive programme of toothbrushing is not effective. The results also tend to show a strong relationship between oral hygiene and gingivitis.

An experimental study was attempted by Løe et al. (1965), to produce gingivitis in patients with healthy gingivae by withdrawing all active efforts directed towards oral cleanliness. At the start of the experimental period assessments were made of all twelve subjects of gingival and oral hygiene conditions according to the criteria of the Gingival Index and Plaque Index Systems respectively.

Subjects were then instructed not to brush their teeth and not to use any other measure of oral hygiene. The subjects' plaque and gingival status were assessed at regular intervals. Once inflammatory changes were observed and assessments made, patients were given detailed instructions in oral hygiene methods. Assessments were continued during this hygiene period. When the Gingival Index and Plaque Index scores approached zero, the experiment was terminated.

During the period of non-cleansing, all subjects accumulated soft debris in large quantities and developed gingivitis. All subjects were well-informed in toothbrush instruction and after oral hygiene measures were reinstated, plaque scores dropped rapidly and gingival inflammation resolved in about one week. At the end of the experiment the mean plaque and gingival index for the whole group dropped to a lower level than at the beginning.

The significance of this experiment was that gingivitis can be produced in subjects with healthy gingivae by removal of oral hygiene procedures. Also, with detailed toothbrush instruction, oral hygiene and gingival condition can be improved.

Lindhe and Koch (1967), conducted an investigation to determine whether careful supervision of toothbrushing had a prolonged effect on the oral hygiene and gingivae in a group of thirteen to fourteen year old children. The subjects were divided into an experimental and a control group, each of 32 children. The toothbrushing of the members of the experimental group was supervised daily for two years and final gingival and plaque scorings were carried out one year later. The control group members were not subjected to any form of supervised or controlled oral hygiene procedures. The gingival and oral hygiene conditions were recorded according to the index system proposed by L  e and Silness (1963) and Silness and L  e (1964).

The results of this investigation clearly showed that the toothbrushing programme only had a marked effect on oral hygiene and gingival conditions during the experimental period. It had no prolonged effect of the oral health of the children, suggesting that oral health care, to achieve a determined level of gingival health among children,

requires constant motivation. However, the gingival and plaque indices in the experimental group were low during the years of supervised oral hygiene.

Suomi, Greene, Vermillion, Doyle, Chang and Leatherwood (1971), published their results of a three year longitudinal study of youths and adults which tested the hypothesis that, after an initial prophylaxis, the development and progression of gingival inflammation is retarded in an oral environment in which high levels of hygiene are maintained. The authors' findings supported this hypothesis.

The abovementioned studies demonstrate that a relationship exists between oral hygiene and gingivitis in non-orthodontic patients. However, these findings have established guiding principles for evaluating the oral health practices of subjects undergoing fixed orthodontic therapy.

5. TOOTHBRUSHING

A. DEFINITION AND AIMS

The most extensively used method to obtain clean teeth is the toothbrush (Sagnes, Zachrisson and Gjermo, 1972).

"Toothbrushing effectiveness may be affected by dentifrice used, by the size and type of the brush, by type and configuration of its bristles, by the brush's power source, and perhaps most importantly, by the methods, skill and frequency with which brushes are used." (World Workshop in Periodontics, Ramfjord et al. 1966)

Hine (1950), stated that the toothbrushing technique should:-

- (1) remove from the teeth all food debris, accumulations of micro-organisms and recently deposited uncalcified supragingival calculus;
- (2) dislodge collections of food debris and accumulation of micro-organisms from the interproximal spaces below contact areas and between the teeth;
- (3) gently massage gingival and gum tissues to promote good blood supply and adequate keratinization of epithelium;
- (4) not irritate or lacerate gingival tissues.

B. METHODS OF TOOTHBRUSHING

i). Description

A review of the literature on toothbrushing reveals that most methods used for cleansing the teeth can be grouped into seven general categories based on motion. (Greene, 1966). All these techniques have possible implications for the orthodontic patient.

These techniques are:-

- i) Vertical
- ii) Horizontal Scrub Technique
- iii) Roll Technique
- iv) Vibratory Techniques
 - (a) Charters'
 - (b) Stillman's Method
 - (c) Bass
- v) Circular (Fones') Method
- vi) Physiologic Technique
- vii) Haphazard Method

ii) Comparison of Techniques

Instead of prescribing one brushing method to all patients, the situation of each individual patient should be evaluated and then an appropriate brushing technique recommended and utilized to satisfy the unique situation.

A review of prominent authorities, for example Shick and Ash, 1961; Frandsen, Barbano, Suomi, Chang and Burke, 1970; Hansen, and Gjermo, 1971; on the comparison of effectiveness of the various

toothbrushing techniques reveals that there are no significant differences between the methods in the reduction of inflammation or disclosing stain.

Studies to compare the relative effectiveness of toothbrushing techniques are faced with many serious problems. (Ramfjord et al. 1966). These problems include inadequacy of methods to measure effectiveness, the great variety of toothbrush designs, variation in manual dexterity of patients, and difficulties in teaching the methods in a standard way.

iii) Toothbrushing Techniques Employed During Orthodontic Treatment

Oral hygiene is greatly complicated following the placement of fixed orthodontic appliances. Failure to manage plaque removal properly may lead to periodontal involvement. (Zachrisson and Alnaes, 1973).

Investigations by Sagnes (1974), and Frandsen et al. (1972) comparing the different toothbrushing techniques indicate that with respect to plaque control, the best cleansing effect has been obtained with horizontal techniques.

No reports have been made concerning the clinical effectiveness of the various recommended methods of toothbrushing in orthodontic patients for preventing gingivitis. (Zachrisson and Zachrisson, 1972a and Zachrisson, 1978a.) Bergenholtz (1971) found vertical brushing to be inadequate along the gingival tooth areas. Horizontal brushing methods imply active brushing all the time. On the basis of the limited evidence available, Zachrisson (1974), recommends horizontal brushing with either the scrub or Bass technique as the

method of choice for patients wearing orthodontic appliances.

The horizontal brushing procedure suggested by Zachrisson (1974), for patients wearing orthodontic appliances, is mainly a back-and-forth scrub motion on the buccal and lingual surfaces. Fig. (2). The toothbrush is placed horizontally, gingival to the arch wire. This is important because care should be taken to avoid bracket interference, which will reduce cleansing efficiency.

In order not to risk unnecessary abrasion, short strokes covering segments of approximately two teeth are used. The brushing is performed with moderate pressure, ten times per segment, and the procedure is repeated throughout the mouth. On the lingual surfaces of anterior teeth, brushing with an up-and-down motion may be easier to perform. Special attention should be paid to the buccal surfaces of maxillary posterior teeth, where the masseter muscle resists ready access, and to non-banded teeth distal to those carrying bands. The remaining tooth surfaces are also cleaned by scrubbing motions.

In contrast, the technique suggested by Woods (1955) to be used on patients with orthodontic appliances, is basically the roll technique.

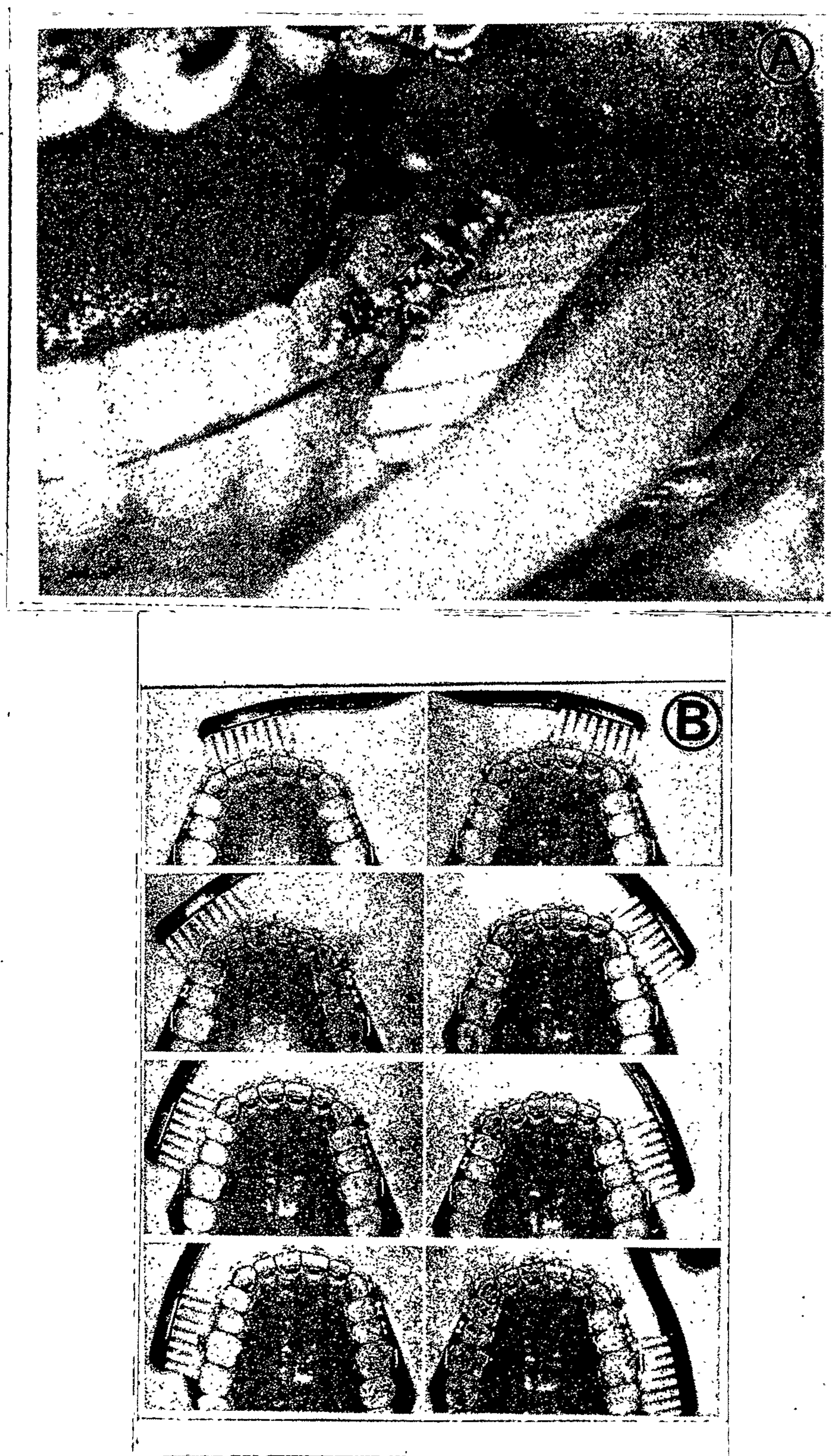


FIG. 2: A recommended horizontal brushing procedure with the scrub method for patients wearing orthodontic appliances.

- A. shows the correct toothbrush position when the scrub technique is used.
- B. indicates the segmentwise (approximately two teeth) brushing, as applied to the buccal surfaces of the maxillary teeth.

(from Zachrisson, 1964)

C. TOOTHBRUSH TYPE

The toothbrush is designed primarily to promote cleanliness of the teeth and oral cavity. It must conform to individual requirements in size, shape and texture, and be easily and effectively manipulated.

i) Toothbrush Configuration

Studies conducted by Hiniker and Forscher (1954), Shick and Ash 1961 and Bergenholtz, Hugosan and Sohlberg (1967), to evaluate the plaque-removing ability of different tooth brush configuration in regard to bristle material, hardness, and arrangement have shown no significant differences. Sagnes, Zachrisson and Gjermo (1972), concluded that no toothbrush can be regarded as being superior to another.

ii) Toothbrush Configuration in the Orthodontic Patient

According to Woods (1955), innumerable types of toothbrushes can be used for orthodontic patients. However, these brushes should be rather small, as the patients are unable to get around the appliances with the larger brushes.

Zachrisson (1974), more specifically supports the concept that toothbrushes to be recommended for horizontal brushing in orthodontic patients should be small, medium-hard or soft, nylon bristled and multitufted.

iii) Powered v. Manual Brushes

Several studies have evaluated the effect of manual and powered brushes in their action on gingivitis reduction and plaque removal.

From these, Greene (1966), concluded that:-

- a. the automatic toothbrush and the manual toothbrush can be used with equal effectiveness in removing and preventing the formation of dental plaque.
- b. neither the manual nor the automatic toothbrush is clearly superior with regard to gingivitis reduction.

iv) Powered v. Manual Toothbrushes for the Orthodontic Patient

Evaluation of the effectiveness of removing or preventing dental plaque and reducing gingivitis using manual or power brushes in children wearing fixed orthodontic appliances has been reported.

Kobayashi and Ash (1964), compared the effectiveness of the arcuate brush and a natural bristle manual toothbrush in preventing or removing dental plaque and reducing gingivitis. Both brushes were found to be equally effective.

In contrast, Womack and Guay (1968), reported the electric toothbrush to be superior over a nylon bristle manual toothbrush in cleansing efficiency.

D. FREQUENCY OF BRUSHING

In order to prevent dental caries, Kitchin (1956), recommended brushing the teeth after every meal and at bed time. However, the value of doing this has never been proven, nor is it known how often it is necessary to brush to prevent and control periodontal disease. According to Glickman (1964), regular brushing of teeth will prevent the accumulation of bacterial plaque, food debris, and calculus and thus prevent gingivitis. Bergenholtz (1971), stated that the optimal frequency of plaque removal depends upon a number of individual factors, such as the physical and chemical properties of the diet, eating habits, individual resistance, and the composition of the microflora.

Several investigations have attempted to correlate gingival inflammation and oral hygiene status with frequencies of reported daily toothbrushing. Stanmeyer (1957), Greene and Vermillion (1960), Horton, Zimmerman and Collings (1969), and Dale (1969), in their studies found a decrease in gingival inflammation and debris scores with increasing reported brushing frequency. From these studies, which were conducted primarily on persons with little or no periodontal disease, it was found that brushing twice a day maintains a healthy gingiva and brushing more frequently has relatively little additional benefit.

From a two month study by Goldman (1956), the author concluded that brushing once a day is sufficient for persons with healthy gingiva, but that brushing three times a day is better for those with periodontal disease.

Alexander (1970), assessed gingival inflammation and bacterial plaque in two groups of two hundred individuals and found these factors to be related to the frequency of toothbrushing. In a group of 200

dental students, brushing more frequently than once daily resulted in less extensive bacterial plaque on their teeth but had no significant effect on the prevalence and extent of gingival inflammation. In a group of 200 patients attending a dental hospital, brushing more frequently was associated with a lower prevalence and extent of gingival inflammation and bacterial plaque. The benefits reached an optimum when the people brushed twice daily.

With regard to maintaining gingival health, L  e, Fehr and Schi  tt (1972) demonstrated that gingiva can remain clinically healthy with complete removal of plaque only once every second day.

From the abovementioned reports on the frequency of toothbrushing, it is difficult to determine how frequently the teeth should be brushed. Suomi (1971) claims that since there exists no evidence that proper, frequent toothbrushing is harmful to the teeth or gingiva and because individuals vary in their efficiency of toothbrushing, it seems unnecessary to place an upper limit on the frequency of toothbrushing. Enough evidence is at hand, however, to justify suggesting at least two brushings daily.

Zachrisson (1974), feels justified, from the existing evidence, to suggest that patients wearing fixed orthodontic appliances should accomplish plaque removal by thorough toothbrushing twice daily, preferably after breakfast and at bed time. It is also advisable to clean the teeth shortly after meals in order to remove food debris.

E. CONCLUSION ON TOOTHBRUSHING

From the available evidence there appears to be no one brushing technique which is clearly superior to other methods of toothbrushing. The method recommended to a patient should be selected only after a thorough analysis of the dentition and the patient. The method and toothbrush of choice depends on the patient's oral health, manual dexterity, personal preference and his ability and desire to learn and follow prescribed procedures.

No definite superiority has been shown for either natural or synthetic bristles or for manually or electrically powered toothbrushes with respect to plaque prevention and removal and gingivitis reduction.

The data on optimum toothbrushing frequency suggest that the teeth should be brushed thoroughly at least two times every day to maintain oral cleanliness and a healthy periodontium.

With regard to patients wearing fixed orthodontic appliances, there is limited evidence available on toothbrushing in respect of plaque removal and prevention and gingivitis reduction. However, the toothbrushing method of choice appears to be the horizontal technique. The toothbrush of choice should be small, medium hard or soft, nylon bristled and multi-tufted. With regard to frequency of toothbrushing, these patients should accomplish plaque removal twice daily.

B. ORIGINAL WORK

INTRODUCTION

This investigation was based on the examination of eighty subjects who were patients attending the Orthodontics Clinic, Department of Preventive Dentistry, University of Sydney. This study was conducted to determine and evaluate the effects of fixed orthodontic appliances and plaque on the gingival tissues.

The aim of the study was to test the hypothesis that bacterial plaque is the single most important aetiological factor responsible for gingival inflammation during orthodontic therapy. Gingival responses were evaluated over a three month period for their prevalence, severity, incidence; and the influences of age and sex were also considered.

The examinations were made and recorded by one examiner, the author.

1. SELECTION OF SUBJECTS

At the time of the initial examination the subjects were between the ages of 11.2 to 23.7 with a mean age of 15.17 years. Each subject was a patient of the Orthodontic Clinic. The clinic caters for children considered to be from a low to lower-middle socio-economic background.

The selection of subjects for this study was based on the criteria of all subjects possessing a malocclusion. They were separated into two groups. One group comprised subjects who were receiving orthodontic treatment by the Begg light-wire technique. The other group consisted of patients who were on a waiting list to be treated for their malocclusion.

The subjects were selected at random at the start of the study. They were mainly late adolescents or older individuals which ruled out study of the likely significance of hormonal effects. Patients with known systemic disease (e.g. diabetes) were not included.

2. SAMPLE SIZE

Many factors determine the number of subjects considered to be necessary in a clinical trial. (Chilton, 1974). The sample size was restricted by availability of suitable subjects to conform to the criteria of the study.

The sample size for a clinical trial also depends on the expected variation among the subjects with regard to gingival response to the presence of orthodontic appliances and plaque. The expected variation was estimated from previous studies. (Zachrisson and Zachrisson, 1972a and 1972b).

Determination of sample size was therefore a problem as it was thus necessary to have an evaluation of the possible magnitude of the effects. In view of the time involved and difficulty in procuring subjects, it was not practicable to run a pilot study.

Prior to starting the study the author consulted with a statistician and described the type of experiment and expected outcomes. The sample size was calculated to hopefully produce a clinically meaningful difference between the two major variables at a stated level of significance. It was advised that a total of eighty subjects would be adequate for this purpose. This number then established the sample size to be used in testing the stated hypothesis.

3. FORMATION OF GROUPS

The subjects were divided into four groups of twenty subjects on the basis of whether a supervised oral hygiene program was instituted or not, and the presence or absence of fixed orthodontic appliances.

In this study the term 'experimental group' refers to that group of subjects who were under a supervised regime of oral hygiene instruction.

The term 'control group' refers to a contrasted group of subjects acting as a standard of comparison. This group did not receive supervised oral hygiene instruction but maintained their normal brushing habits throughout the study.

The subjects were assigned to the groups in a random fashion. As patients from the experimental group were required to be assessed at two-weekly intervals, the only limiting criteria to their selection was geographic availability. Where problems of access to the Clinic or schooling demands arose, these subjects were allocated to the control group.

Stratification of the subjects on the basis of the secondary variables of sex and age was conducted to ensure that both groups had an equal number of subjects of each sex (with approximately the same mean age).

4. EXPERIMENTAL DESIGN

Both experimental and control group subjects were further equally divided on the basis of the presence or absence of fixed orthodontic appliances.

The subjects were thus assigned to four groups of twenty, each group undergoing different treatments:

Group I : Experimental Group - Bands (EB)

Subjects in this group wore fixed orthodontic appliances, and systematic plaque control was undertaken professionally every two weeks. The subjects were instructed in tooth-brushing.

Group II : Experimental Group - No Bands (ENB)

Subjects in this group possessed a malocclusion but were not being treated orthodontically. These subjects were given toothbrush instruction and recalled as for Group I every two weeks for plaque control (conducted by the author).

Group III: Control Group - Bands (CB)

These subjects were currently under orthodontic treatment. Any plaque present was left in situ for the duration of the study. The subjects continued their habitual cleaning methods.

Group IV : Control Group - No Bands (CNB)

This group of subjects did not wear orthodontic appliances. No supervised plaque control was undertaken. The subjects continued their habitual cleaning methods.

5. ORAL HYGIENE REGIMENS

A supervised oral hygiene instruction program was instituted for subjects in the experimental groups. Subjects in Groups I and II were recalled every two weeks and given professional tooth cleaning by the author. Axelsson and Lindhe (1974), have shown that children maintained on a system of professional tooth cleaning every two weeks had low plaque scores (0.3) and only negligible signs of gingivitis (0.25). However, this was without the presence of fixed orthodontic appliances.

A horizontal toothbrushing procedure recommended by Zachrisson (1974) for orthodontic patients was utilised for all experimental group subjects. These patients at their initial examination were given detailed instruction, both verbal and demonstration, in toothbrushing technique. Patients were then tested for their recall of the instructions.

Where possible, parents were invited to participate in the initial and later examinations. A small, soft, nylon bristled multi-tufted toothbrush as suggested by Zachrisson (1974) was issued at this examination, which the subjects used at home and all future clinical assessments.

All subsequent examinations took approximately fifteen minutes. Only when all plaque deposits had been removed by the subject or examiner were they dismissed and another appointment made. During these later assessments toothbrushing instruction was continually emphasised.

6. MEASUREMENTS AND ASSESSMENTS

A. TYPES OF MEASUREMENT - INDICES

All four groups were subjected to an initial examination which involved:

- (1) Assessment of plaque using the Plaque Index of Silness Løe (1964)
- (2) Assessment of gingivitis using the Gingival Index of Løe Silness (1963).

The selection of these indices was based on:

- (1) The ability of these indices to reflect accurately and reliably, changes in gingival health and oral hygiene status.
- (2) The acceptance of using these indices in partial scoring of the mouth and using these scores as representative of the whole mouth. (Greene & Vermillon, 1964; Shick and Ash, 1961; and Jamison, 1968).
- (3) Their proximity to satisfying the requirements of an index as proposed by Davies (1968).

i) Examination for Plaque

This was carried out using the Plaque Index of Silness and Løe (1964). This index system was utilized by the author as the index to assess oral hygiene status because:

- (1) It is the only index which measures plaque thickness at the gingival margin.
- (2) It distinguishes between severity and location.
- (3) It is simple to use with minimal instruments required.
- (4) It can be used in small or large groups.
- (5) It matches the Gingival Index.

Criteria for Plaque Index

- 0 - no plaque in the gingival area.
- 1 - a film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may only be recognised by running a probe across the tooth surface.
- 2 - moderate accumulation of soft deposits within the gingival pocket, or on the tooth and gingival margin which can be seen by the naked eye.
- 3 - abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin.

In this study a partial-mouth method of scoring, after Silness & Løe (1964), was used for assessing the whole-mouth score. The plaque thickness on six teeth representing the six segments of the jaws were examined. The teeth examined were:

- The maxillary right first molar
- The maxillary right lateral incisor
- The maxillary left first bicuspid
- The mandibular left first molar
- The mandibular left lateral incisor
- The mandibular right first bicuspid.

ii) Examination of Gingival Inflammation

This was recorded using the Gingival Index of Løe & Silness (1963). This index system was chosen for this study because the criteria is entirely confined to the qualitative changes in the gingival soft tissue.

Criteria for the Gingival Index System

- 0 - normal gingiva, absence of inflammation
- 1 - mild inflammation - slight change in colour and some oedema
- 2 - moderate inflammation - moderate redness, oedema and glazing.
Bleeding on probing.
- 3 - severe inflammation - marked redness and oedema. Ulceration.
Tendency to spontaneous bleeding.

Gingivae at six teeth representing the six segments of the jaws were examined, to match the same six teeth as used in the Plaque Index.

Scoring according to these two index systems requires light, drying of the teeth and gingiva (Plaque Index only), hand mirror, and a blunt periodontal probe as advocated by L  e (1967).

As both the Plaque Index and Gingival Index systems were used in the present study, the assessment of plaque always preceded that of gingiva.

In the scoring procedure, missing teeth (for example congenitally absent or extracted for orthodontic purposes) were substituted by an adjacent tooth of the same type, as suggested in the index systems proposed by Greene & Vermillon 1960, and Quigley & Hein, 1962.

B. PARTIAL MOUTH SCORING

A partial mouth method of scoring was used for assessing the whole mouth score. As discussed in the Literature Review there are diverse opinions on this form of scoring.

For this study the teeth originally used by L  e & Silness (1963) were chosen.

C. PHOTOGRAPHIC ASSESSMENT

After completion of the plaque and gingival assessments the teeth were stained with Floran disclosing solution. A standardised colour photograph was taken of the stained anterior teeth of each subject.

Results of photographic recording encouraged the author to use colour photography as a means of reviewing gingivitis and oral hygiene assessments. However, photographic assessments were not used in conjunction with the Plaque and Gingival Indices for quantifying the oral hygiene status.

7. DURATION OF THE STUDY

The present study was conducted over a three-month period. Mandel (1974) feels there is no "conventional wisdom" on the length of time to adequately test procedures that alter plaque or debris.

There are no experimental data to indicate the length of time necessary to adequately test procedures that alter plaque. In toothbrushing studies most investigations have employed 30 - 60 day periods. (Stanmeyer, 1957; Greene & Vermillon, 1960; Horton, Zimmerman & Collings, 1969; and Dale, 1969).

Plaque reaches about 90 per cent of its final weight (thirty days without toothbrushing) in about eight days (Mandel, 1974). In experimental gingivitis studies most subjects exhibit gingivitis in about 21 days. This indicates that clinical studies measuring amount of plaque should be a minimum of 8 days and preferably up to 21 days. This time period would be best for mouthwash studies without brushing.

In the present study a much longer time period was indicated

since the control groups (Groups III & IV) were engaged in some form of physical plaque removal whilst continuing with their habitual cleaning methods. Mandel (1974), feels it is impossible to say whether a thirty to sixty day period is adequate to really assess effectiveness. Certainly a longer period would be preferable.

This study involved the prevention and/or reduction of gingivitis following a prophylaxis. Thus the length of the study was made of sufficient duration to allow firstly the effect of the prophylaxis to subside (2 - 3 weeks), and secondly the time required to demonstrate any prevention or reduction of the gingivitis by supervised oral hygiene procedures. In view of these factors the present study was extended over a period of three months duration.

8. STANDARDISATION PROCEDURES

A. STANDARDISATION OF PHYSICAL EQUIPMENT

To obtain consistent results, the equipment used was standardised and kept uniform throughout the course of the study. Fig. (3).

i) Illumination

A constant source of light was used. For the grading of gingivitis it was considered important for the light source to be colour true. Examinations in natural light were avoided as the times of the examination varied and therefore were not consistent with the lighting conditions. The light source used was a standard Siemens lamp attached to the dental unit.

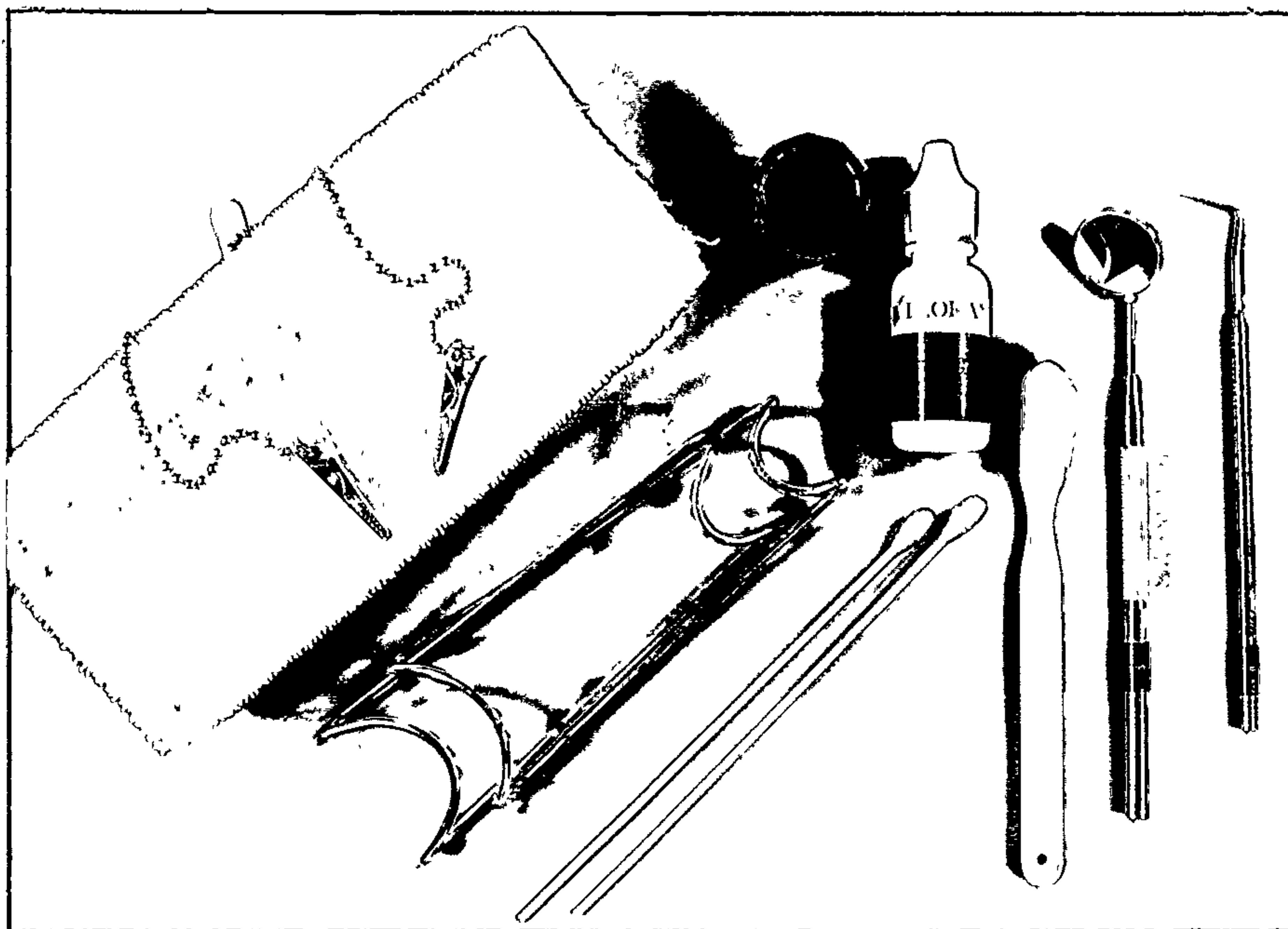


FIG. 3: Standard equipment used throughout duration of the trial.

ii) Drying of Teeth and Gingiva

The procedure for drying the teeth and gingiva during assessment was kept uniform throughout the trial. For assessing gingivitis, drying with an air blast can blanch the tissue, and drying with cotton can increase the apparent inflammation. Therefore, during Gingival Index assessments there was no manipulation of the gingival tissues. For assessing oral hygiene, however, during Plaque Index examinations, the teeth were dried with a blast of air to remove saliva. No cotton was used as this can interfere with the soft deposits.

iii) Mirrors

Plane, front-surface mouth mirrors of the Ash variety were used. All scratched mirrors were replaced.

iv) Periodontal Probes

Two Vetter periodontal probes with Williams markings were selected and used for the duration of the study. These (blunt) probes were of the same thickness to give the same sensitivity and reproducibility in assessing gingivitis and plaque thickness.

v) Disclosing Solution

After plaque and gingival assessments were concluded all the teeth were stained with Floran disclosing solution. At this point colour photographs of the stained anterior teeth were taken. Only members of the experimental groups were given supplementary oral hygiene instructions, using the disclosing solution as a clinical aid.

vi) Camera

Standardised colour photographs were taken of the stained anterior teeth of all subjects at each examination. All photographs were taken with an Olympus OM2 camera using a 3.5/50 mm. macro lens with

a 25mm extension tube and a Sunpak GX8R ring flash set at half power. The aperture was fixed at f22 to give maximum depth of focus.

vii) Toothbrush

All subjects in the experimental groups were issued with a small, soft, nylon bristled, multi-tufted toothbrush.

No definite superiority has been shown for either natural or synthetic bristles or for manually or electrically powered toothbrushes with respect to plaque prevention and removal and gingivitis reduction.

Zachrisson (1974) specifically supports the concept that toothbrushes to be recommended for horizontal brushing in orthodontic patients should be small, medium hard or soft, nylon bristled and multi-tufted.

B. EXAMINER REPRODUCIBILITY

This is a problem with all evaluation indices. The greater the number of subjective decisions and the less precise the criteria, the greater the variability.

Standardisation and calibration on reproducibility is essential, regardless of whether one or more observers are used. (Clemmer & Barbano, 1974; Davies et al, 1967; Ramfjord, 1973; Smith et al, 1970).

In this study all assessments of the Gingival and Plaque Index were conducted by one examiner, the author. Work by Davies et al.(1967) showed that single-examiner reproducibility is better than with multiple examiners. Oliver, Holm-Pederson and L  e (1969) claim that the reproducibility of the Gingival Index is good.

Smith et al (1970) reported that even after a short period of training, examiners were able to duplicate their own scores 80 per cent of the time.

The clinical trial did not commence until consistency of recording assessments had been achieved. The author in conjunction with the head of the Department of Periodontics practised scoring the Plaque Index and Gingival Index assessments on both dental students and patients with periodontal disease.

After a training period, a group of students was scored separately by each examiner for both indices half-an-hour apart.

The results after paired scoring showed a reproducibility on the part of the author of 81.25 per cent for the Plaque Index and 85.41 per cent for the Gingival Index.

The inter-examiner reproducibility was 63.54 per cent and 65.62 per cent respectively.

Examination of the results would suggest that the author scored more severely on the low scores than the trained observer.

In considering the results from the Gingival Index scoring, least agreement was reached on the decision between not inflamed and slightly inflamed, the early stages of inflammation, i.e. between scores of 0 and 1. Reproducibility was greater where gingival inflammation was more severe.

TABLE 1
Intra-Examiner Reproducibility
Paired Scores - Plaque Index Scoring

First Observation	Second Observation				
	0	1	2	3	
	0	6	8		4 subjects examined
	1	4	58	3	24 teeth examined
	2		3	14	96 surfaces examined
	3				

Agreement - 78 surfaces
Total surfaces - 96
% Agreement paired scores - 81.25

TABLE 2
Inter-Examiner Reproducibility
Paired Scores - Plaque Index Scoring

Second Examiner	First Examiner				Second Examiner	First Examiner			
	0	1	2	3		0	1	2	3
	0	4	6			0	2	1	
	1	11	38	10		1	14	34	10
	2		8	19		2		13	22
	3					3			

Agreement - 61 surfaces	Agreement - 58 surfaces
Total surfaces - 96	Total Surfaces - 96
% agreement paired scores = 63.54	% agreement paired scores = 60.41

TABLE 3
Intra-Examiner Reproducibility
Paired Scores - Gingival Index Scoring

First Observation	Second Observation				
	0	1	2	3	
	0	2	6		4 subjects examined
	1	1	55	5	24 teeth examined
	2		2	25	96 surfaces examined
	3				

Agreement - 82 surfaces
Total surfaces - 96
% agreement paired scores = 85.41

TABLE 4
Inter-Examiner Reproducibility
Paired Scores - Gingival Index Scoring

First Examiner	Second Examiner				First Examiner	Second Examiner			
	0	1	2	3		0	1	2	3
	0	3	2			0	2	1	
	1	4	38	13		1	5	38	12
	2		17	19		2		15	23
	3					3			

Agreement - 60 surfaces	Agreement - 63 surfaces
Total surfaces - 96	Total surfaces - 96
% agreement paired scores - 62.45	% agreement paired scores = 65.62

As this testing of reproducibility was conducted on dental students whose oral hygiene and gingival status was most reasonable, often the amount of plaque and gingival inflammation was slight and this may account for the reproducibility being between 60 to 65 per cent on the inter-examiner comparison for the two indices.

The training period allowed time for the examiner to produce results which were consistent and showed minimal differences when confronted by identical conditions at varying times. For all parameters of gingivitis and oral hygiene this reproducibility was measured during the study by randomly recalling ten per cent of the subjects for a second examination during the same session. The time interval between examinations was usually 30 minutes, which was considered long enough to avoid any bias due to the examiner's memory.

Alterations in oral hygiene and gingival status between the examinations were assessed by paired comparisons. In the case of the plaque situation there was an increase in the number of 0 scores and a decrease in the number of 1 scores from the first to the second examination. Inconsistency of the scores was recorded for 13.02 per cent of the surfaces. The plaque situation was found to be improved on eighteen surfaces and worsened on seven surfaces.

TABLE 5
Intra-Examiner Consistency
Paired Scores - Plaque Index Scoring

Second Observation	First Observation				
	0	1	2	3	
	0	20	10		8 subjects recalled
	1	4	83	8	48 teeth re-examined
	2		3	60	192 surfaces re-examined
3				4	
Agreement - 176 surfaces					
Total surfaces - 192					
% agreement paired scores = 86.97%					

TABLE 6
Intra-Examiner Consistency
Paired Scores - Gingival Index Scoring

Second Observation	First Observation				
	0	1	2	3	
	0	7	3		Agreement - 150 surfaces
	1	10	56	4	Total surfaces - 192
	2		22	80	% agreement paired scores = 78.12
3			3	7	

When examining the paired scores for gingivitis, there was an increase in the number of Gingival Index 2 scores per person between examinations. The mean number of surfaces with a changed score was found to be 5.25 surfaces per subject (21.87 per cent of the surfaces). The number of scores which increased exceeded the number of scores which decreased.

Re-examination within half-an-hour of either the plaque or the gingival situation suggested that there has been an improvement of oral hygiene and a worsening of the gingival condition. These alterations may be due to measurement and/or systematic errors.

If the scoring changes were caused by measurement errors (intra-examiner inconsistency), the same amount of positive and negative differences would have been expected.

Birkeland & Jorkjend (1975), have suggested explanations for the differences encountered:-

- a. During the first assessment of oral hygiene, some plaque may have been removed by the dental probe. This accounts for the reduction in the number of scores of 1 and improvement in the plaque situation.
- b. Since the tendency to bleeding is the predominant criteria of the Gingival Index system, the first examination might have increased the bleeding tendency and accordingly resulted in an increase in the number of scores of 2 indicating a worsening of the gingival conditions.

As the author's results are in agreement with the suggestions of Birkeland et al (1975), systematic error rather than intra-examiner inconsistency is what was assessed when the two consecutive recordings were made within half-an-hour of each other.

9. EXAMINATION FREQUENCY

A base-line examination was conducted for all subjects. Members of both experimental groups (Groups I & II) were examined throughout the study at two-weekly intervals as suggested by Axelsson & Lindhe (1974). Thus, over the three month study period, these participants were examined and assessed for oral hygiene and gingival status a total of seven times.

Members of the control groups (Groups III & IV) were assessed twice throughout the study, at the base-line examinations and at the termination of their three month period.

10. INFORMATION COLLECTED AT BASE-LINE

In addition to the information regarding the parameters of gingival inflammation and plaque, the following information was also recorded at the base line examinations:-

- a. Name of subject
- b. Date of Birth
- c. Sex
- d. Date of examination

11. SEQUENCE OF EXAMINATION

After the necessary base-line information had been provided by each participant the examination procedure for all subjects was:-

- a. Plaque Index assessment
- b. Gingival Index assessment
- c. Photograph of anterior teeth after staining
- d. Oral hygiene regimens for experimental groups.

12. STATISTICAL HANDLING

This study concerns a multi-factorial problem. The effect on the gingival tissues of both the presence and absence of fixed orthodontic appliances must be considered, as well as the effect of plaque control. Both of these treatments may have an effect and to test this we must establish two groups of subjects, one receiving plaque control (EB) and one with removal or absence of orthodontic appliances (CNB); plus a control group of subjects receiving neither treatment (CB).

Consideration must also be made as to whether absence of fixed orthodontic appliances together with removal of plaque has a supplementary effect, and if so, whether it is purely additive or a more complicated effect. To do this a fourth group of subjects who are not undergoing orthodontic treatment but are receiving plaque control is required (ENB).

As well as these first-order interactions, we must consider interactions (second-order interactions) which may occur with other known factors such as age and sex, as the author desired to test if these interactions were significant.

The use of an orthogonal factorial design (Smart, 1963) allows an analysis of variance which provides the opportunity to test simultaneously a number of main effects and interactions and second-order interactions. The factorial design allows the simultaneous study of all the factors involved, both first-order and second-order interactions (Armitage, 1971).

One requirement of a factorial design analysis is that the groups contain equal numbers and are thus balanced. This requirement was satisfied in the present study, where each of the four groups

contained twenty subjects. The male-to-female ratio was simultaneously balanced.

The criteria of the Gingival and Plaque Index systems are based on non-equidistant differences between consecutive scores. Thus the analysis of the Gingival and Plaque Index scores presents a problem due to this ordinal character of the scoring systems. It is not possible to calculate the results on the assumption that two scores of 1 is equivalent to a score of 2, or that a score of 3 indicates three times the severity of a score of 1. Hence, sophisticated mathematical techniques on averaging are not permitted and thus are not subject to analysis with conventional statistics such as the factorial design.

The analysis of the plaque and gingival scores can be approached in two different ways:-

- a. The use of non-parametric statistics requiring the use of tests such as the Mann-Whitney U-Test, where the significance of the difference between the two independent groups can be derived.
- b. The other approach is to use frequency to generate a derived score. This score is the proportion of tooth surfaces in any situation which gain a plaque or gingival score of zero or one (0, 1). This has been termed the G-Ratio (Murrell, Highfield and Powell, 1978). This ratio has the best numerical qualities except that its distribution is unlikely to be normal in the mathematical sense. In such a case an angular transformation may be used in the analysis of variance (Armitage, 1971). The transformed value:-

$$x^1 = \text{arc sine } x \text{ where } x \text{ is the raw proportional score.}$$

This expression is read:

"The transformed score is the angle whose sine is the square root of the original score".

Use of this angular transformation allowed an analysis of variance to be used for the plaque and gingival scores.

(The statistical handling was conducted by a member of the Department of Mathematical Statistics, University of Sydney.)

C. RESULTS

GENERAL ANALYSIS:

The results show that plaque is associated with gingival inflammation, and this inflammatory reaction is more pronounced in the presence of fixed orthodontic appliances.

A significant difference ($p < 0.01$) was found in the amount of plaque accumulated around orthodontic appliances as compared to the amount of plaque present in the mouths of patients not wearing orthodontic appliances. This difference in plaque accumulation was reflected in the significantly higher experience of gingival inflammation of the patients wearing appliances. ($p < 0.01$).

Concerning different locations in the mouths significant differences were found in both gingival inflammation and plaque accumulation. Posterior teeth were significantly more affected than anterior teeth ($p < 0.001$), and the interproximal surfaces were significantly more affected than facial surfaces ($p < 0.001$).

Fixed orthodontic appliances were found to have a greater influence on the gingival inflammation and plaque accumulation in males than females. As the difference was not significant the subjects were not differentiated on the basis of sex. Any hormonal influences on gingival inflammation which may have been present may have been masked by the fact that the majority of subjects were beyond puberty.

Regular professional plaque control had a significant ($p < 0.01$) and favourable effect upon the gingival tissues both in the presence and absence of fixed orthodontic appliances.

In each group of twenty subjects, six teeth, comprising 24 surfaces per subject were examined. Thus within each group there were 480 surfaces. The frequency of occurrence of Gingival Index (G.I.) and Plaque Index (P.I.) scores of 0, 1, 2, 3 was calculated and analysed for each group (Tables 7, 8, 9 and 10.).

In this analysis the severity of gingival inflammation was considered at two levels. One level comprised gingival tooth surfaces having normal gingivae or showing signs of mild gingivitis (G.I. = 0,1). The other consisted of gingival surfaces where the severity of inflammation was found to be moderate or severe (G.I. = 2,3).

This form of severity rating has been termed the G-Ratio (Murrell, 1976). Thus the derived G-Ratios were used for comparative purposes. The percentage frequency of one G-Ratio is the complement of the other.

TABLE 7.

GINGIVAL INDEX - INITIAL SCORES

INDIVIDUAL SURFACE SCORES - 24 SURFACES - NUMBERS OF SCORES 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)				GROUP II (ENB)				GROUP III (CB)				GROUP IV (CNB)			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
MALES																
1	0	6	13	5	1	11	12	0	0	5	14	5	1	8	15	0
2	0	5	17	2	1	9	14	0	0	5	15	4	0	12	12	0
3	0	4	11	9	1	10	13	0	1	5	14	4	10	6	8	0
4	1	7	12	4	2	12	10	0	0	9	14	1	2	12	10	0
5	1	6	11	6	0	15	9	0	0	9	10	5	0	5	19	0
6	0	9	15	0	5	9	10	0	1	5	11	7	3	9	12	0
7	0	7	10	7	6	5	13	0	0	4	12	8	2	10	12	0
8	0	4	20	0	5	9	10	0	0	7	11	6	0	10	14	0
9	0	4	12	8	10	5	9	0	0	4	15	5	0	13	11	0
10	1	4	9	10	0	4	20	0	0	6	13	5	2	9	13	0
FEMALES																
1	0	6	14	4	3	9	12	0	2	5	8	9	0	14	10	0
2	1	8	15	0	5	9	10	0	0	11	13	0	2	9	13	0
3	0	7	14	3	4	9	11	0	1	4	16	3	0	11	13	0
4	0	7	9	8	1	8	15	0	1	5	15	3	8	10	6	0
5	0	5	19	0	0	17	7	0	1	6	17	0	0	9	15	0
6	0	5	19	0	2	12	10	0	1	3	16	4	0	12	12	0
7	1	5	18	0	0	8	16	0	0	6	11	7	2	14	8	0
8	0	5	14	5	0	2	18	4	0	11	13	0	5	6	13	0
9	1	6	14	3	8	11	5	0	1	4	19	0	0	8	16	0
10	1	5	18	0	2	11	11	0	2	5	17	0	1	9	14	0
	7	115	284	74	56	185	235	4	11	119	274	76	38	196	246	0

TABLE 8.
GINGIVAL INDEX - FINAL SCORES

INDIVIDUAL SURFACE SCORES - 24 SURFACES - NUMBER OF SCORES 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)				GROUP II (ENB)				GROUP III (CB)				GROUP IV (CNB)			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
MALES																
1	7	7	10	0	4	12	8	0	0	4	15	5	5	8	11	0
2	6	9	9	0	4	10	10	0	0	5	15	3	3	6	15	0
3	2	10	12	0	2	17	5	0	0	6	16	6	6	12	6	0
4	4	14	6	0	7	11	6	0	0	8	16	4	4	11	9	0
5	4	12	8	0	6	15	3	0	0	11	9	0	0	4	20	0
6	3	15	6	0	10	9	5	0	0	5	13	1	1	10	13	0
7	4	13	7	0	6	11	7	0	1	1	16	0	0	9	15	0
8	7	9	8	0	9	12	3	0	0	8	11	5	5	15	9	0
9	5	10	9	0	13	7	4	0	0	3	14	3	3	10	11	0
10	5	10	9	0	0	11	13	0	0	5	15	4	1	10	13	0
FEMALES																
1	4	10	9	1	8	11	5	0	1	3	15	5	0	16	8	0
2	9	11	4	0	11	11	2	0	2	5	14	3	1	12	11	0
3	4	12	8	0	10	7	7	0	0	6	13	5	1	9	14	0
4	5	9	10	0	6	8	10	0	0	6	11	7	5	11	8	0
5	1	14	9	0	6	14	4	0	0	8	13	3	1	8	15	0
6	9	7	8	0	12	8	4	0	1	3	18	2	0	10	14	0
7	4	14	6	0	2	13	9	0	1	4	11	8	2	16	6	0
8	3	11	10	0	0	8	16	0	0	9	15	0	1	9	14	0
9	7	11	6	0	12	9	3	0	0	6	16	2	1	8	15	0
10	5	13	6	0	12	8	4	0	0	7	17	0	2	8	14	0
	98	221	160	1	140	212	128	0	6	113	283	78	37	202	241	0

TABLE 9.

PLAQUE INDEX - INITIAL SCORES

INDIVIDUAL SURFACE SCORES - 24 SURFACES - NUMBERS OF SCORES 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)				GROUP II (ENB)				GROUP III (CB)				GROUP IV (CNB)			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
MALES																
1	3	8	13	0	4	12	8	0	2	7	15	0	5	9	10	0
2	3	8	13	0	2	12	10	0	0	12	12	0	4	11	9	0
3	1	6	14	3	3	13	8	0	4	6	11	3	11	9	4	0
4	1	12	11	0	6	11	7	0	2	13	9	0	5	11	8	0
5	2	11	9	2	3	15	6	0	0	14	6	4	1	11	16	0
6	0	15	9	0	4	11	9	0	2	10	8	4	4	7	7	0
7	0	14	8	2	6	9	9	0	0	9	12	4	2	13	8	0
8	0	11	13	0	5	16	3	0	0	12	8	3	1	12	11	0
9	0	10	9	5	11	8	5	0	2	8	14	0	4	11	9	0
10	1	11	11	1	0	8	16	0	1	13	10	0	1	13	10	0
FEMALES																
1	1	11	12	0	1	14	9	0	1	7	11	5	4	15	5	0
2	2	13	9	0	5	13	6	0	1	15	8	0	3	12	9	0
3	0	13	11	0	9	7	8	0	7	5	12	0	2	12	10	0
4	1	9	14	0	8	5	11	0	3	10	11	0	8	14	2	0
5	2	10	12	0	3	15	6	0	2	10	12	0	2	10	12	0
6	0	12	12	0	7	10	7	0	0	11	7	6	1	15	8	0
7	0	12	12	0	2	10	12	0	2	8	13	1	3	16	5	0
8	1	12	9	2	0	2	13	9	3	15	6	0	9	2	13	0
9	0	12	12	0	11	11	2	0	2	10	10	2	2	8	14	0
10	5	9	10	0	4	12	8	0	7	7	10	0	1	14	9	0
	23	219	223	15	94	214	163	9	41	202	205	32	73	228	179	0

TABLE 10.

PLAQUE INDEX - FINAL SCORES

INDIVIDUAL SURFACE SCORES - 24 SURFACES - NUMBERS OF SCORES 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)				GROUP II (ENB)				GROUP III (CB)				GROUP IV (CNB)			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
MALES																
1	7	11	6	0	9	12	3	0	0	9	14	1	13	5	6	0
2	10	9	5	0	9	10	5	0	0	11	9	4	1	13	10	0
3	2	14	8	0	4	16	4	0	1	9	14	0	13	8	3	0
4	11	10	3	0	12	10	2	0	0	13	11	0	1	14	9	0
5	9	13	2	0	15	8	1	0	0	13	6	5	2	4	18	0
6	11	11	2	0	16	4	4	0	2	12	8	2	5	13	6	0
7	7	14	3	0	19	3	2	0	1	6	12	5	0	14	10	0
8	12	10	2	0	13	9	2	0	0	14	8	2	0	13	11	0
9	6	13	5	0	19	3	2	0	2	8	14	0	1	15	8	0
10	8	10	6	0	7	9	8	0	0	11	13	0	2	15	7	0
FEMALES																
1	6	12	6	0	11	11	2	0	2	6	13	3	3	17	4	0
2	14	10	0	0	15	9	0	0	2	11	11	0	1	15	8	0
3	6	14	4	0	12	11	1	0	3	9	9	3	1	11	12	0
4	6	11	7	0	9	9	6	0	3	12	9	0	3	17	4	0
5	3	17	4	0	12	10	2	0	2	11	11	0	1	12	11	0
6	8	13	3	0	15	7	2	0	1	8	12	3	3	12	9	0
7	6	15	3	0	7	10	7	0	2	8	13	1	6	14	4	0
8	8	12	4	0	0	10	14	0	5	12	7	0	5	7	12	0
9	12	8	4	0	16	8	0	0	0	11	13	0	2	9	13	0
10	8	14	2	0	12	10	2	0	4	8	12	0	3	15	6	0
	160	241	79	0	232	179	69	0	30	202	219	29	66	243	171	0

TABLE 11.

GINGIVAL INDEX

PERCENTAGE FREQUENCY OF TOTAL SURFACES SCORING 0, 1, 2, 3.

TOTAL SURFACES = 480

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	7	1.45	56	11.66	11	2.29	38	7.91
1	115	23.95	185	38.54	119	24.79	196	40.83
2	284	59.16	235	48.95	274	57.08	246	51.25
3	74	15.41	4	0.83	76	15.83	0	0

FINAL SCORE

0	98	20.41	140	29.16	6	1.25	37	7.70
1	221	46.04	212	44.16	113	23.54	202	42.08
2	160	33.33	128	26.66	283	58.95	241	50.20
3	1	0.20	0	0	78	16.25	0	0

TABLE 12.

PLAQUE INDEX

PERCENTAGE FREQUENCY OF TOTAL SURFACES SCORING 0, 1, 2, 3.

TOTAL SURFACES = 480.

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	23	4.79	94	19.58	41	8.54	73	15.20
1	219	45.62	214	44.58	202	42.08	228	47.50
2	223	46.45	163	33.95	205	42.70	179	37.29
3	15	3.12	9	1.87	32	6.66	0	0
FINAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	160	33.33	232	48.33	30	6.25	66	13.75
1	241	50.20	179	37.29	202	42.08	243	50.62
2	79	16.45	69	14.37	219	45.62	171	35.62
3	0	0	0	0	29	6.04	0	0

TABLE 13.

GINGIVAL INDEX

PERCENTAGE FREQUENCY OF INTERPROXIMAL GINGIVAL SURFACES SCORING 0, 1, 2, 3.

TOTAL INTERPROXIMAL SURFACES = 240

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	0	0	7	2.91	0	0	3	1.25
1	10	4.16	55	22.91	15	6.25	74	30.83
2	165	68.75	174	72.50	155	64.58	163	67.91
3	65	27.08	4	1.66	70	29.16	0	0

FINAL SCORE		GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	0	12	5.00	30	12.50	0	0	2	0.83
1	1	102	42.50	106	44.16	17	7.08	62	25.83
2	2	125	52.08	104	43.33	151	62.91	176	73.33
3	3	1	0.42	0	0	72	30.00	0	0

TABLE 14.

GINGIVAL INDEX

PERCENTAGE FREQUENCY OF FACIAL GINGIVAL SURFACES SCORING 0, 1, 2, 3.

TOTAL FACIAL SURFACES = 240

INITIAL SCORE

	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	7	2.91	48	20.0	11	4.58	33	13.75
1	105	43.75	130	54.16	104	43.33	123	51.25
2	119	49.58	62	25.83	118	49.16	84	35.00
3	9	3.75	0	0	7	2.91	0	0

FINAL SCORE

0	86	35.83	108	45.0	6	2.50	35	14.58
1	119	49.58	106	44.16	96	40.00	140	58.33
2	35	14.58	26	10.83	132	55.00	65	27.08
3	0	0	0	0	6	2.50	0	0

TABLE 15.

PLAQUE INDEX

PERCENTAGE FREQUENCY OF INTERPROXIMAL TOOTH SURFACES SCORING 0, 1, 2, 3.

TOTAL INTERPROXIMAL SURFACES = 240.

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	0	0	12	5.00	2	0.83	11	4.58
1	59	24.58	95	39.58	58	24.16	95	39.58
2	170	70.83	126	52.50	151	62.91	134	55.83
3	11	4.58	7	2.91	29	12.08	0	0

FINAL SCORE		GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
0		35	14.58	74	30.83	0	0	5	2.08
1		135	56.25	103	42.91	53	22.08	103	42.91
2		70	29.16	63	26.25	163	67.91	132	55.00
3		0	0	0	0	24	10.00	0	0

TABLE 16.

PLAQUE INDEX

PERCENTAGE FREQUENCY OF FACIAL TOOTH SURFACES SCORING 0, 1, 2, 3.

TOTAL FACIAL SURFACES = 240

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	23	9.58	81	33.75	39	16.25	62	25.83
1	158	65.83	119	49.58	144	60.00	133	55.41
2	55	22.91	38	15.83	55	22.91	45	18.75
3	4	1.66	2	0.83	2	0.83	0	0

FINAL SCORE

0	125	52.08	158	65.83	30	12.50	61	25.41
1	105	43.75	74	30.83	149	62.08	140	58.33
2	10	4.16	8	3.33	56	23.33	39	16.25
3	0	0	0	0	5	2.08	0	0

TABLE 17.

GINGIVAL INDEX

PERCENTAGE FREQUENCY OF ANTERIOR GINGIVAL SURFACES SCORING 0, 1, 2, 3.

TOTAL ANTERIOR SURFACES = 160

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	6	3.75	34	21.25	11	6.87	21	13.12
1	72	45.0	76	47.5	63	39.38	104	65.00
2	73	45.62	49	30.62	81	50.62	35	21.87
3	9	5.62	1	0.62	5	3.12	0	0

FINAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	65	40.62	81	50.62	6	3.75	22	13.75
1	83	51.87	61	38.12	63	39.37	88	55.00
2	12	7.50	18	11.25	85	53.12	50	31.25
3	0	0	0	0	6	3.75	0	0

TABLE 18.

GINGIVAL INDEX

PERCENTAGE FREQUENCY OF POSTERIOR GINGIVAL SURFACES SCORING 0, 1, 2, 3

TOTAL POSTERIOR SURFACES = 320

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	1	0.31	22	6.87	0	0	17	5.31
1	43	13.43	108	33.75	57	17.81	90	28.12
2	211	65.93	187	58.43	192	60.00	213	66.56
3	65	20.31	3	0.93	71	22.18	0	0

FINAL SCORE

0	33	10.31	61	19.06	0	0	15	4.68
1	138	43.12	154	48.12	50	15.62	114	35.62
2	148	46.25	105	32.81	198	61.87	191	59.68
3	1	0.31	0	0	72	22.50	0	0

TABLE 19.

PLAQUE INDEX

PERCENTAGE FREQUENCY OF ANTERIOR TOOTH SURFACES SCORING 0, 1, 2, 3.

TOTAL ANTERIOR SURFACES = 160.

INITIAL SCORES	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	20	12.50	54	33.75	28	17.50	46	28.75
1	100	62.50	80	50.00	87	54.37	88	55.00
2	40	25.00	25	15.62	43	26.87	26	16.25
3	0	0	1	0.62	2	1.25	0	0
FINAL SCORES	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	89	55.62	110	68.75	27	16.87	33	20.62
1	63	39.37	42	26.25	79	49.37	96	60.00
2	8	5.00	8	5.00	54	33.75	31	19.37
3	0	0	0	0	0	0	0	0

TABLE 20.

PLAQUE INDEX

PERCENTAGE FREQUENCY OF POSTERIOR TOOTH SURFACES SCORING 0, 1, 2, 3.

TOTAL POSTERIOR SURFACES = 320.

INITIAL SCORE	GROUP I (EB)		GROUP II (ENB)		GROUP III (CB)		GROUP IV (CNB)	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
0	3	0.93	39	12.18	12	3.75	27	8.43
1	119	37.18	134	41.87	116	36.25	140	43.75
2	182	56.87	139	43.43	163	50.93	153	47.81
3	16	5.00	8	2.50	29	9.06	0	0

FINAL SCORE

0	69	21.56	122	38.12	3	0.93	33	10.31
1	177	55.31	137	42.81	123	38.43	145	45.31
2	74	23.12	61	19.06	165	51.56	142	44.37
3	0	0	0	0	29	9.06	0	0

FREQUENCY PLAQUE INDEX

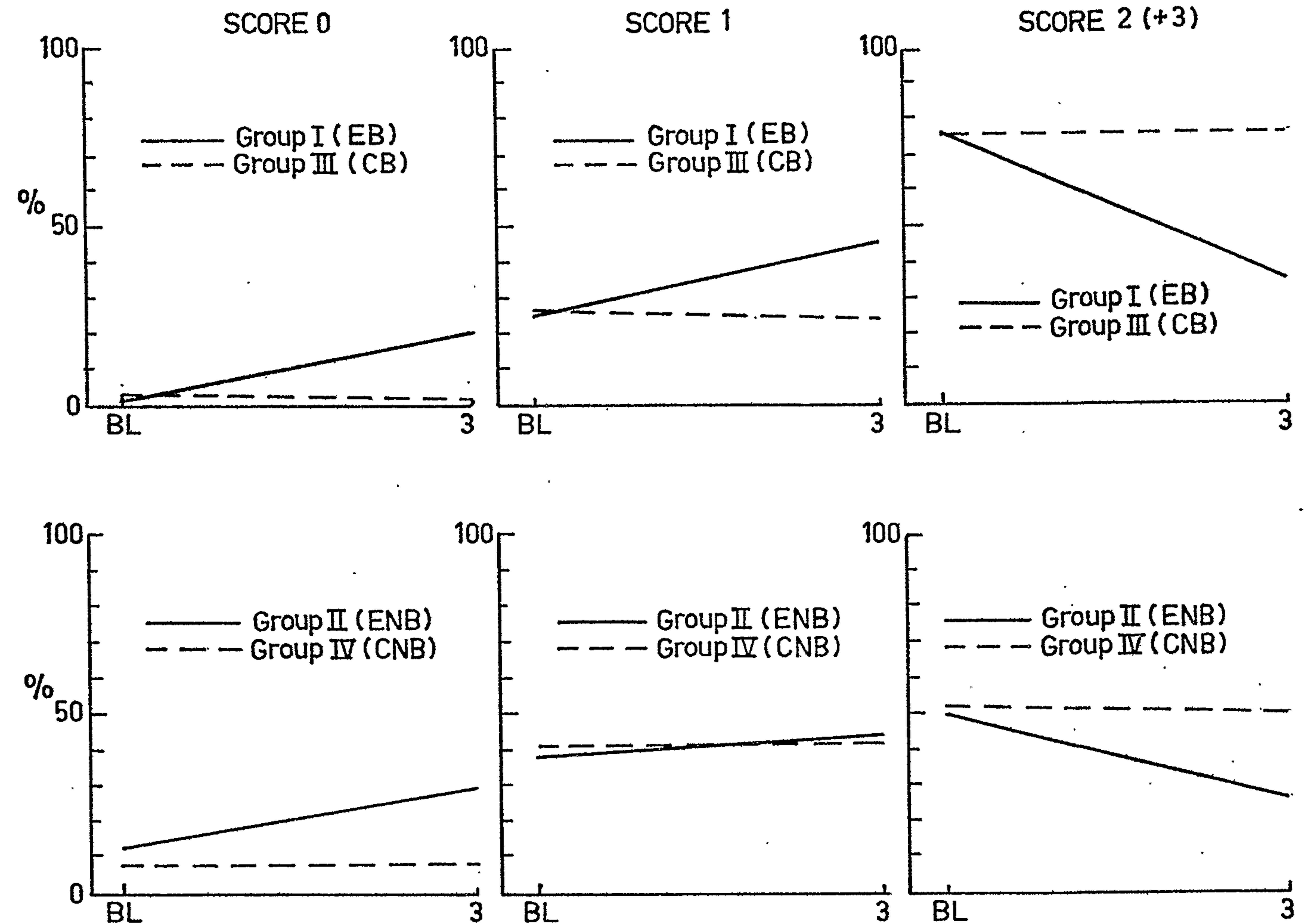


FIG. 4: Frequency Distribution in Groups I, II, III, and IV of surfaces scoring GI = 0, 1, and 2(+3) at the baseline (BL) examination and after three months.

FREQUENCY PLAQUE INDEX

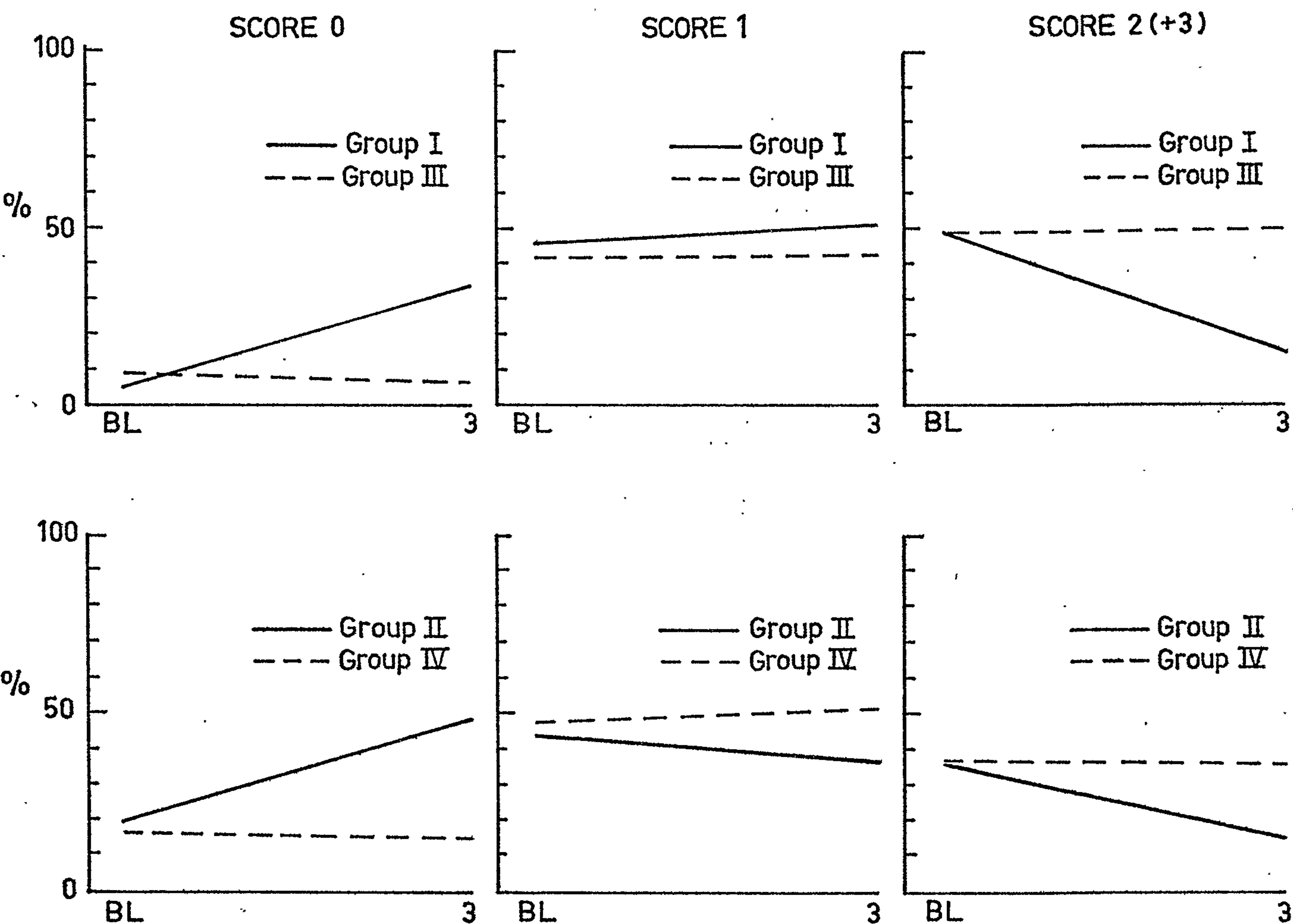


FIG. 5: Frequency Distribution in Groups I, II, III and IV of surfaces scoring PI = 0, 1 and 2(+3) at the baseline (BL) examination and after three months.

1. EFFECT OF FIXED ORTHODONTIC APPLIANCES ON THE GINGIVAL TISSUES
IN CONTROL GROUP SUBJECTS - FINAL SCORES.

From Table 11 final scores it can be seen that the gingivae showed more inflammation of the severe form (G.Ratio 2,3, as defined above) among those wearing appliances than among those not wearing appliances. (75.2% for Group III compared with 50.2% for Group IV). Comparisons for surfaces showing mild gingival scores (G.Ratio 0,1,) may be readily derived from these values.

Differences in the prevalence of severity of gingival inflammation around the teeth in different sites of the mouth were found. A comparison was made of these differences, especially the differences found between anterior and posterior teeth, and between facial and interproximal tooth surfaces.

The severity of gingivitis showed wide variability for the interproximal and facial surfaces, as seen in Tables 13, 14, 24 and 26.

The final scores show:--

- A. Around the interproximal gingival surfaces the frequency of the gingivitis (G.Ratio 2,3,) is high both in the presence and absence of appliances. However, in this region those patients wearing appliances had a greater percentage frequency of this severe form. (92.9% for Group III patients compared with 73.3% for Group IV patients). (Table 13).
- B. Examination of the gingivae surrounding the facial surfaces of the teeth showed that subjects wearing appliances had twice the frequency of G.Ratio 2,3 as compared to those subjects not wearing appliances (57.5% for Group III compared with 27.1% for Group IV). (Table 14).
- C. Tables 13 and 14 show that for subjects wearing appliances the frequency of gingivitis of the severe form, (G.Ratio 2,3), is higher in the interproximal gingival areas than that surrounding the facial areas. (73.3% for interproximal areas as compared to 57.5% for facial areas).

Differences were also found in the prevalence of gingivitis between anterior and posterior tooth surfaces. (Tables 17, 18, 32 and 34). Of the 480 tooth surfaces examined, 160 of these were for anterior tooth surfaces and 320 were posterior tooth surfaces.

From Tables 17 and 18 final scores it can be seen that:-

A. Around anterior tooth surfaces, patients undergoing orthodontic therapy showed a greater frequency of G.Ratio 2,3 than that among those patients not wearing appliances. (56.9% for Group III patients compared with 31.3% for Group IV patients). (Table 17).

B. A greater prevalence of G.Ratio 2,3 among those subjects wearing appliances was also found around the posterior tooth surfaces. Here the percentage frequency was 84.4% for banded patients as compared to 59.7% for non-banded patients. (Table 18).

C. Overall, the severe form of gingival inflammation was more prevalent around posterior teeth than around anterior teeth (Tables 17 and 18). The presence of orthodontic appliances aggravated this situation. In both anterior and posterior regions of the mouth the banded teeth showed relatively high frequencies of G.Ratio 2,3.

2. EFFECT OF FIXED ORTHODONTIC APPLIANCES ON PLAQUE ACCUMULATION IN CONTROL GROUP SUBJECTS - FINAL SCORES.

The derived G-Ratios for plaque were utilised for comparative purposes. A G-Ratio of 0,1 indicated no plaque or a thin film of plaque present on the tooth surface and a G-Ratio of 2,3 suggested abundant plaque accumulation. As was done for gingival inflammation, within each group of twenty subjects, the 480 tooth surfaces were examined and comparisons were made for the prevalence, severity and location of plaque accumulation.

Table 12 final scores show that the prevalence of plaque accumulation of an abundant nature, G-Ratio 2,3 (as defined above), was greater on those tooth surfaces where fixed orthodontic appliances were present. The frequency of G-Ratio 2,3 was 51.7% for Group III compared with 35.6% for Group IV.

Comparisons of the prevalence and severity of plaque thickness between the interproximal and facial surfaces were made. (Tables 15, 16, 28 and 30).

The final scores show:-

- A. Both banded and non-banded subjects had a high prevalence of the abundant type in the interproximal areas. Percentage frequency scores show 77.9% for Group III and 55.0% for Group IV. (Table 15).
- B. The severity of plaque thickness along the facial tooth surfaces showed a high frequency of G-Ratio 0,1 among both banded and non-banded patients. The non-banded patients had a greater prevalence of this mild form of plaque accumulation (83.9% for Group IV compared with 74.6% for Group III), (Table 16).
- C. Irrespective of the presence or absence of orthodontic appliances the percentage frequency of plaque thickness indicating a G-Ratio 2,3 was three-times greater on the interproximal tooth surfaces than on the facial surfaces. (Tables 15 and 16).

The prevalence and severity of plaque thickness on the 160 anterior tooth surfaces and the 320 posterior tooth surfaces were examined. From Tables 19, 20, 36 and 38 final scores it can be seen:

- A. The plaque thickness along the anterior tooth surfaces showed a high frequency of G-Ratio 0,1 for both banded and non-banded subjects. In the absence of orthodontic appliances the percentage frequency was greater than when appliances were worn. (80.6% for Group IV compared to 66.2% for Group III). (Table 19).

B. Examination of the severity of plaque accumulation around the posterior tooth surfaces showed a greater prevalence of the abundant form for banded patients than for non-banded patients. The frequency of G-Ratio 2,3 was 60.6% for Group III and 44.4% for Group IV. (Table 20).

C. Overall, the prevalence of the mild form of plaque accumulation (G-Ratio 0,1) was greater around anterior tooth surfaces, whilst the prevalence of the abundant type (G-Ratio 2,3) was greater around posterior tooth surfaces. When orthodontic appliances were present the relationship was maintained but alterations in the frequency of G-Ratios indicated an increase in the severity of plaque accumulation. (Tables 19 and 20).

3. EFFECT OF FIXED ORTHODONTIC APPLIANCES ON THE GINGIVAL TISSUES AND ON PLAQUE ACCUMULATION IN CONTROL GROUP SUBJECTS - INITIAL SCORES.

The prevalence and severity of gingival inflammation and plaque accumulation at the start of the trial were also examined. (Tables 7, 9, and 11-20).

The parameters of gingival inflammation and plaque accumulation that were investigated in the final scores were also examined for the initial scores.

The control groups behaved as expected, and no significant variation in individual surface scores was noted during the duration of the trial.

4. EFFECT OF FIXED ORTHODONTIC APPLIANCES ON THE GINGIVAL TISSUES AND ON PLAQUE ACCUMULATION IN EXPERIMENTAL AND CONTROL GROUP SUBJECTS - INITIAL SCORES.

The prevalence and severity of gingival inflammation and plaque accumulation at the start of the trial was also assessed for the experimental and control groups. To compare severity ratings the frequency of G-Ratios were again utilised. Comparisons were made of differences found

between banded and non-banded patients, interproximal and facial surfaces and between the anterior and posterior regions of the mouth.

At the base-line examination, all parameters of gingival inflammation and plaque accumulation should theoretically show similar G-Ratios for banded patients of Groups I and III and for non-banded patients of Groups II and IV.

From Table 11 initial scores a similarity is seen in the prevalence and severity of gingival conditions between Group I and Group III (banded subjects), and also between Group II and Group IV (non-banded subjects). A similar trend is seen in the frequency of G-Ratios for plaque accumulation at the base-line examination. (Table 12).

Comparison of initial G-Ratios for the parameters of gingival inflammation and plaque accumulation in relation to different sites in the mouth and on individual tooth surfaces showed no statistically significant differences for the four groups. Any slight differences found may be explained on the basis of intra-examiner variability. (Tables 13 - 20).

5. EFFECT OF SUPERVISED PLAQUE CONTROL

At the completion of the trial the prevalence and severity of gingival inflammation and plaque accumulation around the tooth surfaces were estimated. Changes in the above conditions during this period of supervised plaque control were analysed. The established severity ratings, (G-Ratios), for gingival inflammation and plaque accumulation were utilised.

A. EFFECT OF PLAQUE CONTROL ON THE GINGIVAL TISSUES - FINAL SCORES

From Table 11 it can be seen that for both banded and non-banded patients the gingivae showed a greater frequency of G-Ratio 0, 1, with a higher prevalence in the non-banded patients (66.4% for Group I compared with 73.3% for Group II). This is in direct contrast to the initial scores, indicating improvement in the gingival condition.

Differences in initial and final Gingival Index scores are shown in Table 11 and Fig. 4. Groups I and II had a significant ($p < 0.01$) improvement in gingival health, supporting the hypothesis that gingival inflammation is most reduced if plaque is controlled.

Analysis of variance (Table 40) shows that examination by treatment interaction is significant ($p < 0.01$). Figure 6 and Table 21 shows the weighted group means:-

TABLE 21

	Base line	Final (3 months)
Group I	0.25	0.77
Group II	0.50	0.64
Group III	0.25	0.33
Group IV	0.48	0.39
Examination by treatment interaction (G. 0, 1)		
Weighted mean gingival G-Ratios Gingival Index.		

GINGIVAL INFLAMMATION

Examination by Treatment Interaction
Weighted mean Gingival G(0,1) Ratios

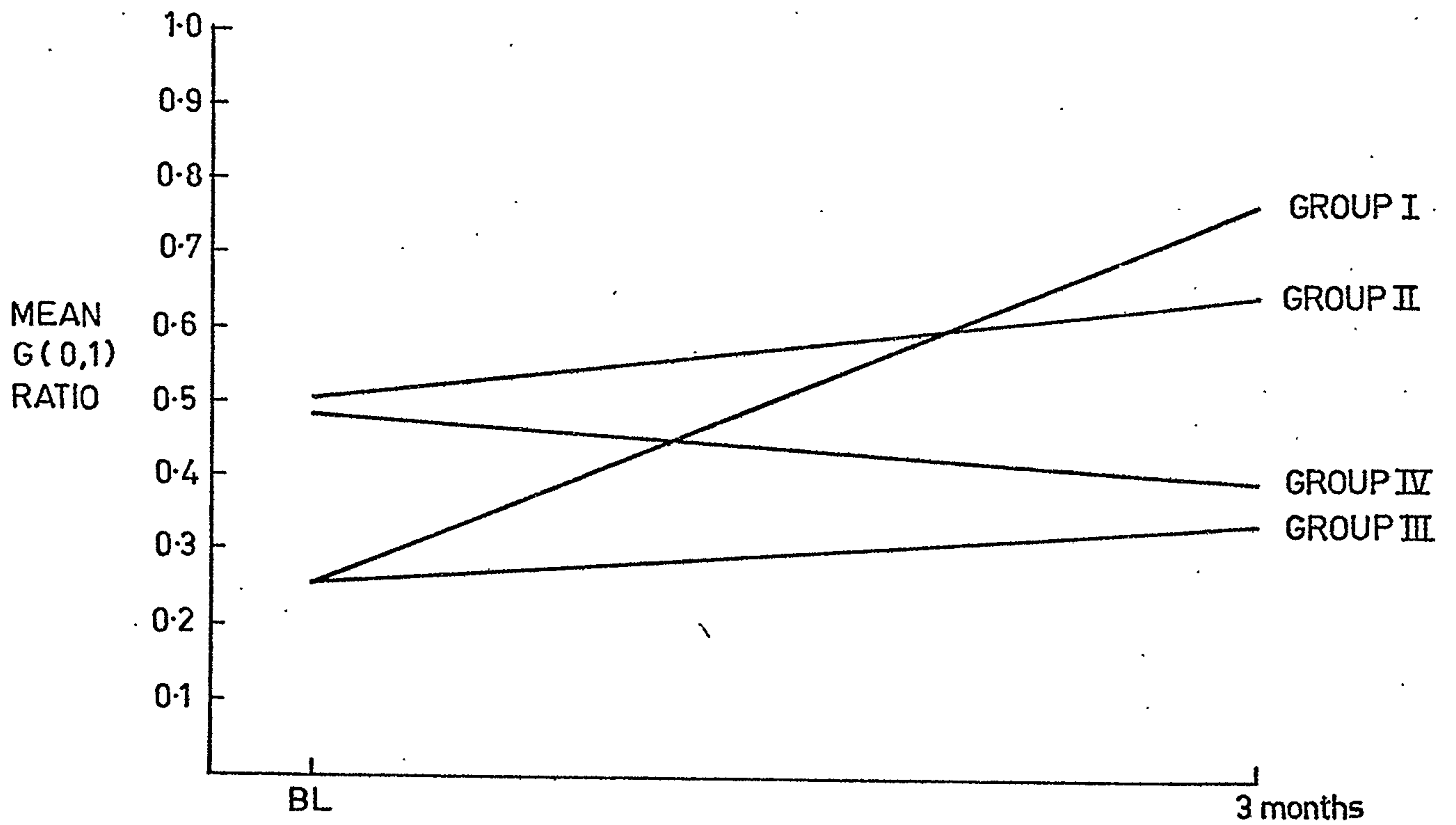


FIG. 6.

B. EFFECT OF PLAQUE CONTROL ON PLAQUE ACCUMULATION -
FINAL SCORES

Differences in initial and final Plaque Index scores are shown in Table 22 and Fig. 5 .

At the completion of the trial the plaque G-Ratio 0,1 was dominant for both experimental groups. Non-banded subjects showed only a slightly higher prevalence of this rating (83.5% for Group I compared to 85.6% for Group II).

Both groups showed significant ($p < 0.01$) increases in the frequency of G-Ratio 0,1, but the banded group showed the greater improvement (Table 12). The frequency distribution of G-Ratio 0,1 for Group I improved from 49.4% to 83.5%, whilst that for Group II increased from 64.1% to 85.6%.

On analysis of variance (Table 42) it was found that examination by treatment interaction is significant ($p < 0.01$). Figure 7 and Table 22 shows the weighted group means:-

TABLE 22.

	Base line	Final (3 months)
Group I	0.50	0.89
Group II	0.64	0.84
Group III	0.51	0.55
Group IV	0.63	0.60
Examination by treatment interaction (G. 0, 1)		
Weighted mean plaque G-Ratios. Plaque Index.		

Between the initial and final examinations, alterations in plaque and gingival G-Ratios for the different sites of the mouth and

PLAQUE ACCUMULATION

Examination by Treatment Interaction

Weighted mean Plaque G(0,1) Ratios

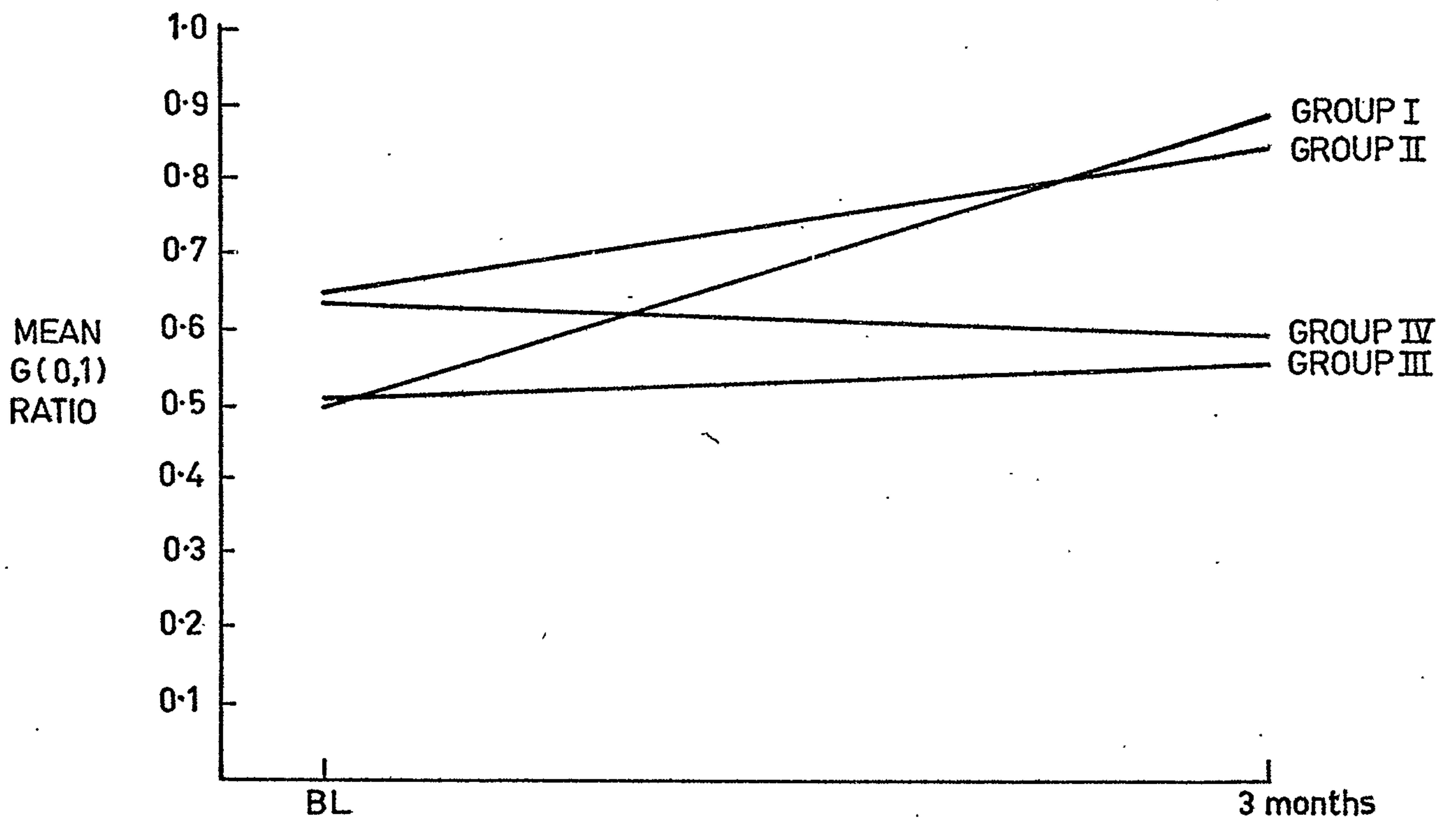


FIG. 7.

different locations on the tooth surfaces were seen in both experimental groups.

i) In the Interproximal Areas - Final Scores :-

a) The increase in frequency of G-Ratio 0, 1 for gingival surface scores was greater in Group I than in Group II. However both groups showed a significant increase ($p < 0.01$) (Tables 13 and 44).

b) The percentage frequency of Plaque Index surface score 0, 1 increased more significantly in Group I than in Group II. Group I increased by 46.2% ($p < 0.01$) compared to 29.1% for Group II ($p < 0.01$). (Tables 15 and 46).

ii) On Facial Areas of Tooth and Gingiva:-

a) The frequency of G-Ratio 0,1 along gingival surfaces showed a greater increase in Group I than in Group II. In Group I this mild form of gingivitis increased in frequency by 38.7%. ($p < 0.001$) compared to 15.0% for Group II. ($p < 0.01$). (Tables 14 and 44).

b) Along facial tooth surfaces alterations in the frequency of Plaque G-Ratio 0, 1 for the two groups was not as dramatic as for the gingiva. In Group I there was a significant increase of 20.4% ($p < 0.01$) and in Group II a significant increase of 13.4% ($p < 0.01$). This is explained on the basis that the initial G (0, 1) frequencies for plaque were relatively high. (Tables 16 and 46).

iii) Anterior Teeth:-

a) The frequency of the mild form of gingivitis showed a significant increase of 43.7% ($p < 0.01$) for banded patients, compared with an increase of 18.9% for non-banded patients ($p < 0.01$) (Tables 17 and 48).

b) An increase in the frequency of plaque G-Ratio 0, 1 along anterior tooth surfaces was found to be significant for both Groups I ($p < 0.01$) and Group II ($p < 0.01$). The banded group increased in frequency by 20.0% compared to 6.2% for the non-banded group. (Tables 19 and 50).

iv) Posterior Teeth:-

a) During the trial the percentage frequency of Gingival Index surface scores 0, 1 significantly increased in both experimental groups ($p < 0.01$). Group I posterior tooth surfaces showed the greater increase. The differences were 38.8% for Group I and 26.8% for Group II. (Tables 18 and 48).

b) The plaque G-Ratio 0, 1 showed a significant increase for both Group I by 39.7%, and for Group II by 26.6% ($p < 0.01$). (Tables 20 and 50).

Differences in the initial Gingival Index scores between the various groups were tested with a student t-test. Table 51 shows the results of the tests.

Significant differences ($p < 0.01$) were found between the groups when comparing banded to non-banded groups.

Over the three month period Groups I and II showed significant improvement in Gingival Index scores ($p < 0.01$). (Tables 27 and 51 and Fig.4). In testing the difference of the means of the transformed final scores, Groups I and II showed a significant difference ($p < 0.01$), whilst Groups III and IV showed no significant difference.

The effect of supervised plaque control is shown in Table 52. Groups I and II showed a significant improvement ($p < 0.01$), with the greater improvement in Group I.

The results were subjected to significance tests. The frequencies of P.I. = (0, 1), and G-Ratios for the initial and final Plaque Index scores were tested with a student t-test. Table 52 shows the results of the tests.

Significance tests showed no significant differences in the initial plaque scores between the banded and non-banded groups. ($p < 0.05$). (Table 51).

A significant improvement in Plaque Index was found for both experimental groups ($p < 0.01$). (Table 51).

Significance tests on the means of the final Plaque Index scores showed a significant ($p < 0.01$) difference between experimental and control groups. (Table 52).

D. DISCUSSION

The findings confirm the claim by Socransky (1970) that the most important aetiological factor responsible for periodontal breakdown is the presence of bacterial plaque.

The results indicate that the severity of the gingival inflammation is a linear function of the gingival debris. This is in agreement with Greene (1960, and 1963), Russell (1963) and Brandtzaeg, (1964).

Furthermore, in the presence of fixed orthodontic appliances bacterial plaque at the gingival margin was again found to be the main causal factor responsible for the gingival inflammation. This supports the claims of Zachrisson, (1976).

As found by Zachrisson and Zachrisson (1972a), these gingival changes resulting from the presence of plaque were found to be of greater severity in patients undergoing orthodontic therapy.

Mechanical irritant effect of fixed orthodontic appliances has been cited as a predisposing cause of gingival inflammation. (Stuteville, 1938; Dummet, 1951; Woods, 1955). However, in the present study it was shown that this supplementary inflammation of the gingiva was most likely due to the increased plaque retention potential of these appliances. (Arnim et.al, 1959 and 1961; Balenseifen and Modonia, 1970; Zachrisson and Zachrisson 1972a; Klaehn and Pfeifer, 1974).

The greater number of plaque retention areas induced by the presence of fixed orthodontic appliances was reflected in the condition of the gingival tissues prior to professional plaque control.

Subjects wearing fixed appliances were found to be amenable to plaque control measures. Similarly, subjects not wearing appliances

were also found to be amenable to plaque control measures, but to a lesser extent. This was reflected in the final plaque scores of the experimental group subjects (Table 12).

This was also reflected in the gingival conditions at the completion of the trial. The severity of gingival inflammation was less in those subjects not wearing fixed appliances. However, during the trial period, banded subjects showed a greater response to these plaque control measures by showing a more significant improvement in gingival health.

Recent studies on the effect of fixed orthodontic appliances and plaque on gingival inflammation have been conducted by Zachrisson and Zachrisson (1972a and 1972b) and Klaehn and Pfeifer (1974). The effects of professional plaque control in preventing or reducing gingival inflammation in the present study, although encouraging, were not as dramatic as those obtained by the above mentioned authors. This study contained a much smaller number of patients than the Zachrisson study and was extended over a much shorter time period. However, Day and Shourie (1947) in their study observed that the incidence and severity of gingival disease is related to social and economic status. The sample for the present study was drawn from a sector of the population considered to belong to a low to lower-middle socio-economic background.

A number of problems were encountered in assessing plaque accumulation:-

1. The first is one of subject manipulation, in that many patients prior to attending the dentist clean their teeth to the best of their ability giving an assessment of plaque that does not reflect the usual state of their mouth. In contrast, Gingival Index scores are not subject to such manipulation. This problem of obtaining an accurate assessment of plaque may have been responsible to some degree for the difference in initial interproximal plaque G-Ratios 0.1 for Groups II and IV. Intra-examiner

variation may also have accounted for this discrepancy.

2. The second and more important problem lies in our method of assessing plaque. The Plaque Index used in this study attempts to assess plaque thickness at the gingival margin. The criteria are not well-defined and they are entirely subjective. This is one of the criteria of the Silness and Løe Plaque Index System (1964) which does not meet the ideal requirements of an Index System as proposed by Davies (1968) and Massler et al. (1950)

3. Another problem encountered in utilising the Plaque Index System (1964) was that it assesses only supragingival plaque. Thus, any sub-gingival plaque along the band margins below the gingival crest remained unregistered (Silness, 1970). This applied specifically to orthodontic bands positioned on posterior teeth, which were in direct contact with the gingival tissues. This is in direct contrast to anterior teeth, where the orthodontic bands which were cemented on the central parts of the crowns registered lower plaque scores.

A difference in Plaque Index scores between anterior and posterior teeth was also found by Zachrisson and Zachrisson (1972a). The difficulty of access to posterior teeth for brushing purposes may also have contributed to the higher plaque scores in this region of the mouth.

As the Plaque Index System lacks the precision to assess sub-gingival plaque, perhaps one should consider the use of more sophisticated techniques such as plaque weight as suggested by Mandel (1974).

4. The obvious problem of accurately measuring interproximal plaque must also be overcome. To do this, Ainamo (1970) examined the interproximal areas from both buccal and lingual aspects and assigned the greater index value to the mesial or distal surface.

The results of the present study were in accordance with previous findings (Zachrisson and Zachrisson, 1972a and 1972b) where interproximal surfaces invariably had higher Plaque Index scores than facial areas.

Some problems in assessing gingival inflammation were also encountered. As remarked by Russell (1956), disagreement may easily occur at the point of deciding whether a given area of free gingiva is normal or slightly inflamed.

As reflected in the low Plaque Index scores, the cleaning habits of the subjects were satisfactory. Even patients with almost perfect tooth cleaning showed a mild inflammatory reaction. However, severe inflammation was not observed as frequently as reported by Spence (1955), and this may be explained by the regular recording and supervision of the hygiene status.

Lindhe and Koch (1967) proposed that fluoride might be retained in dental plaques over prolonged periods and induce or aggravate the inflammatory process. As participants of the present study were drawn from areas of a fluoridated water supply, results on gingival inflammation scores may have been affected. However, more recent reports indicate an insignificant effect of fluoride on gingival conditions (Birkeland, Jorkjend, and von der Fehr, 1971; Axelsson and Lindhe, 1975).

Prior to starting the trial, the subjects were not on a systematic periodic prophylaxis program, and the initial plaque and gingival scores may appear high. On the other hand, the criteria for GI. = 0 are hard to fulfil. (Zachrisson and Zachrisson, 1972a). By means of supervised toothbrushing every two weeks, low scores were obtained.

The effects of supervised toothbrushing on the cleanliness of the enamel and inflammation of the gingivae were also recorded by standardised colour photographs as illustrated in Figs. 8 and 9.

Alterations in plaque accumulation and gingival conditions were also observed in control group subjects over the duration of the trial. As expected the overall changes as seen in Figs. 10 and 11 for both banded and non-banded patients were of minor extent. Over the trial period these patients received no supervised toothbrushing instruction, but continued with their normal brushing habits.

Not all subjects in the experimental groups responded successfully to professional plaque control over the three-month trial period. Figure 12 of the subject (Index number 8), a 17½ year old unemployed girl from a broken home show effects of poor motivation in oral care.

The Gingival Index scores were consistently higher at the interproximal surfaces than at the facial surfaces. These findings are in accordance with previous observations (Baer and Coccaro, 1964; Zachrisson and Zachrisson, 1972a and 1972b). Perhaps other methods of interdental cleaning should supplement careful toothbrushing during orthodontic therapy. (Gjeramo and Flotra, 1970).

In the present study, the author considered the use of a special type of dental floss (Super-Floss). This product is supplied with one relatively rigid end for ease of insertion into the interproximal areas. The rigid end is threaded from the buccal side and would pass under the orthodontic archwire. However, the author decided against utilising this product. It was felt that after teaching new brushing techniques to the majority of patients, the added chore of flossing may have been expecting too much from these young subjects.

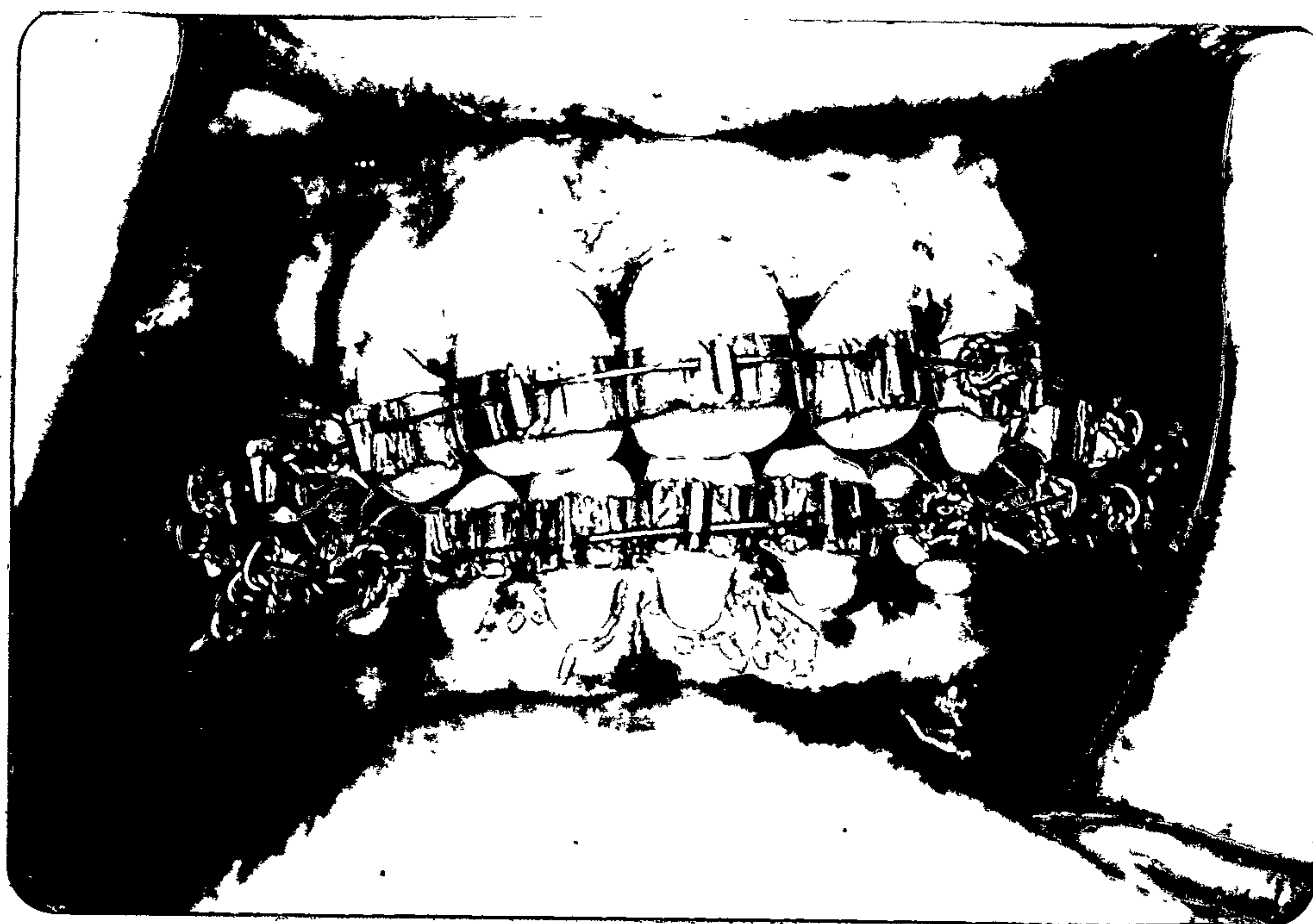
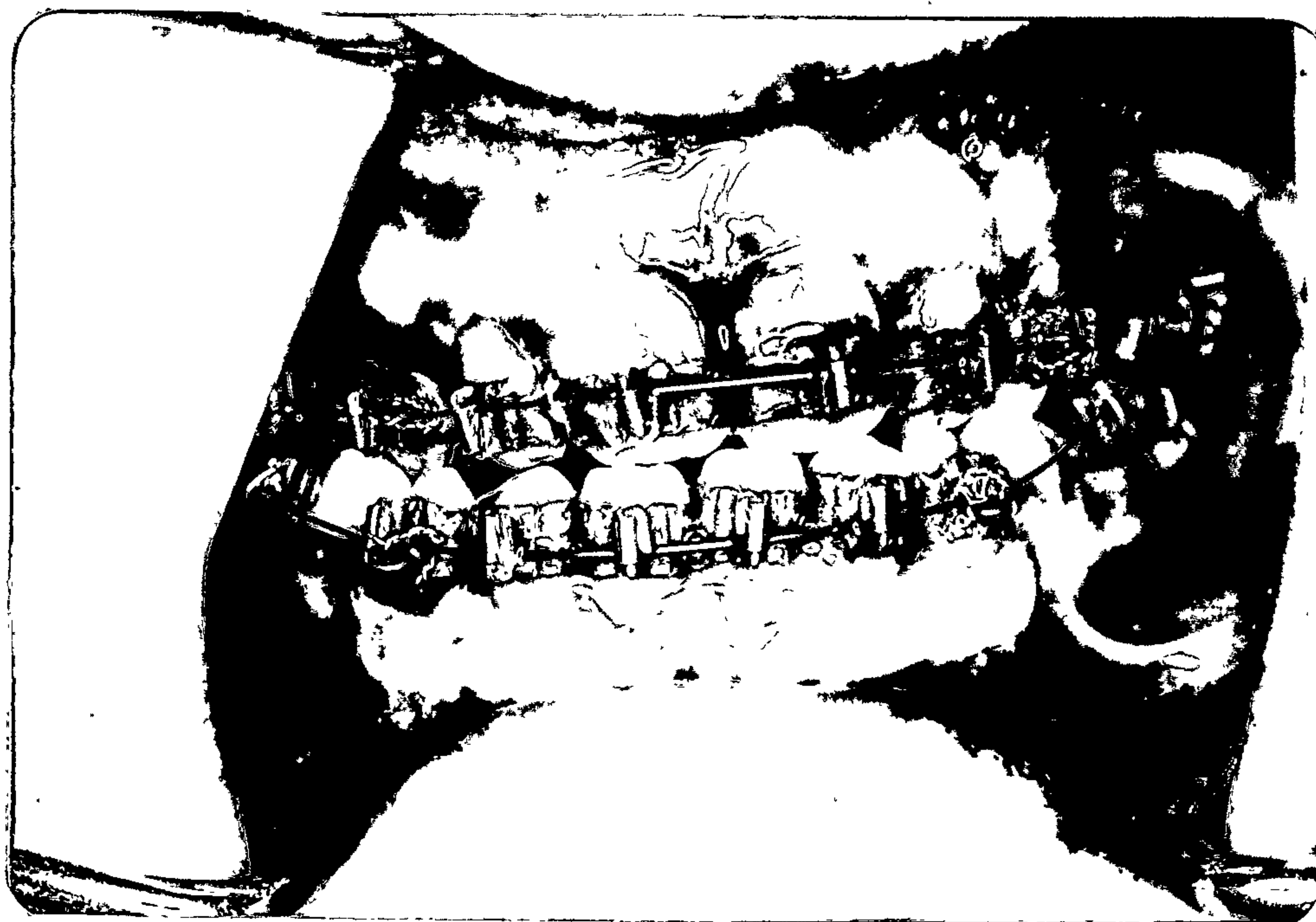


FIG. 8: Colour photographs of stained anterior teeth showing gingival and oral hygiene status at the baseline examination and after three months for a subject in Group I - Experimental Bands.



FIG. 9: Colour photographs of stained anterior teeth showing gingival and oral hygiene status at the baseline examination and after three months for a subject in Group II - Experimental No Bands. Photograph at final assessment reveals gingival enlargements suggesting possible patient manipulation (toothbrushing) prior to clinical examination.

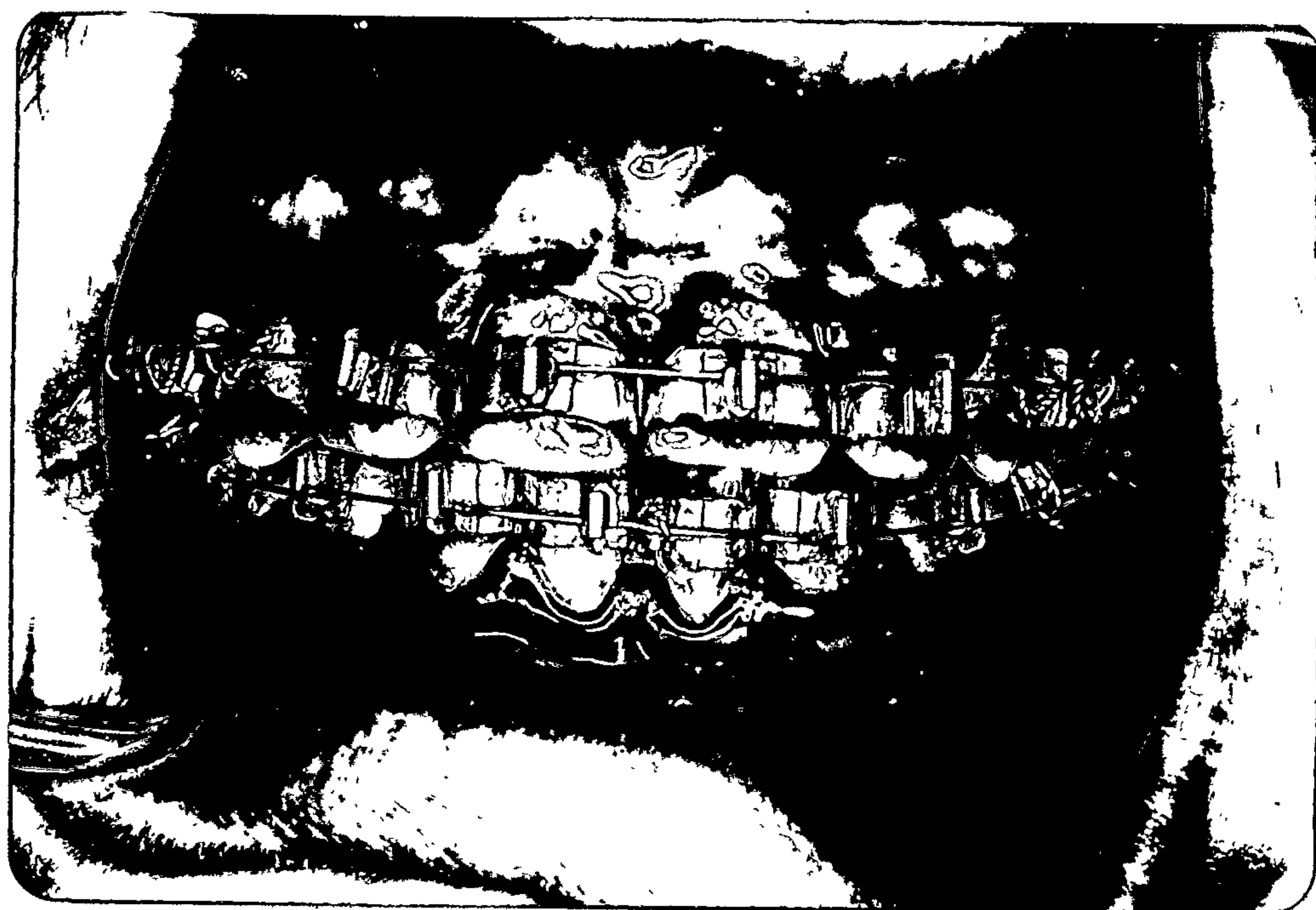


FIG. 10: Colour photographs of stained anterior teeth showing gingival and oral hygiene status at the baseline examination and after three months for a subject in Group III - Control Bands.



FIG. 11: Colour photographs of stained anterior teeth showing gingival and oral hygiene status at the baseline examination and after three months for a subject in Group IV - Control No Bands.

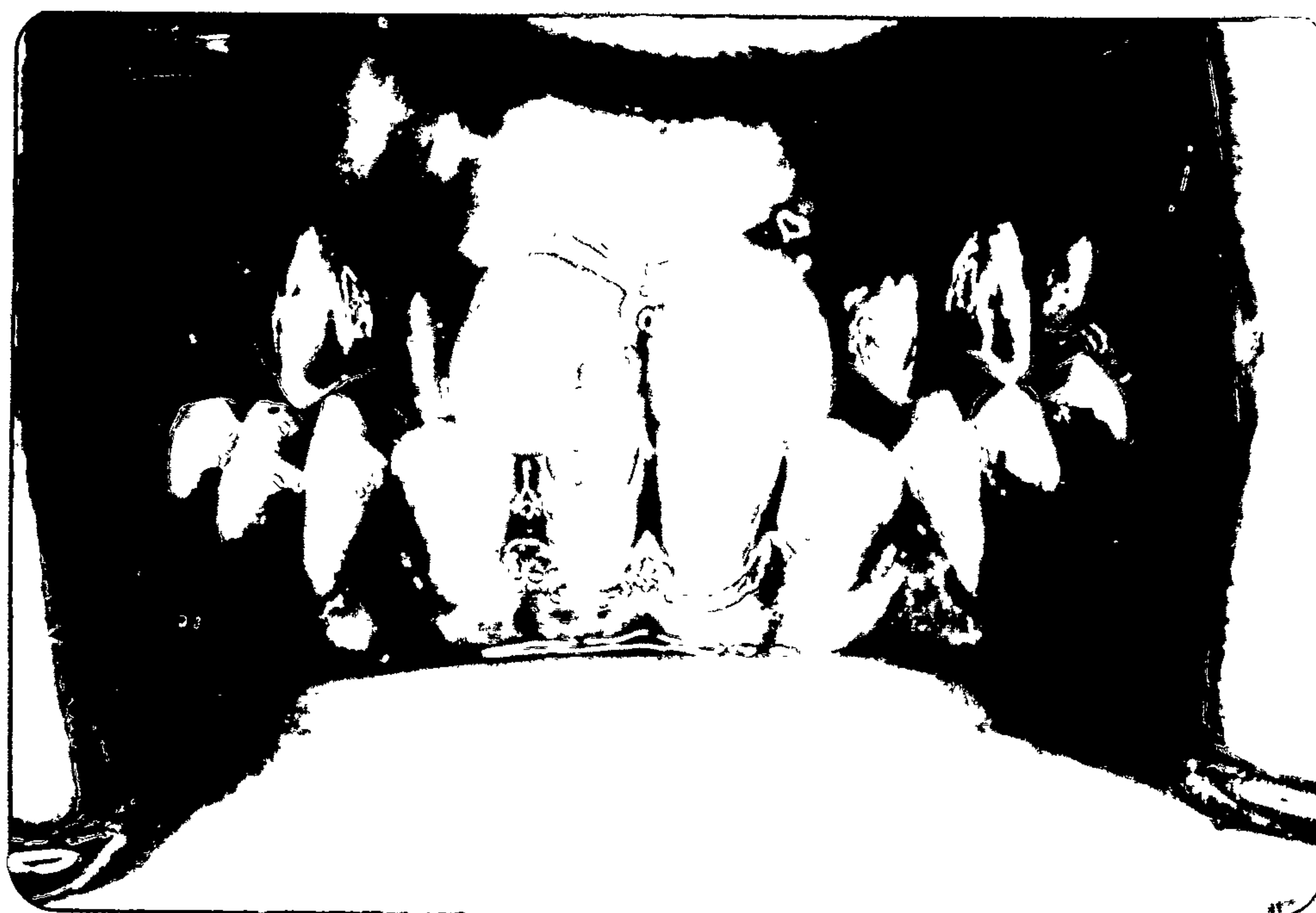
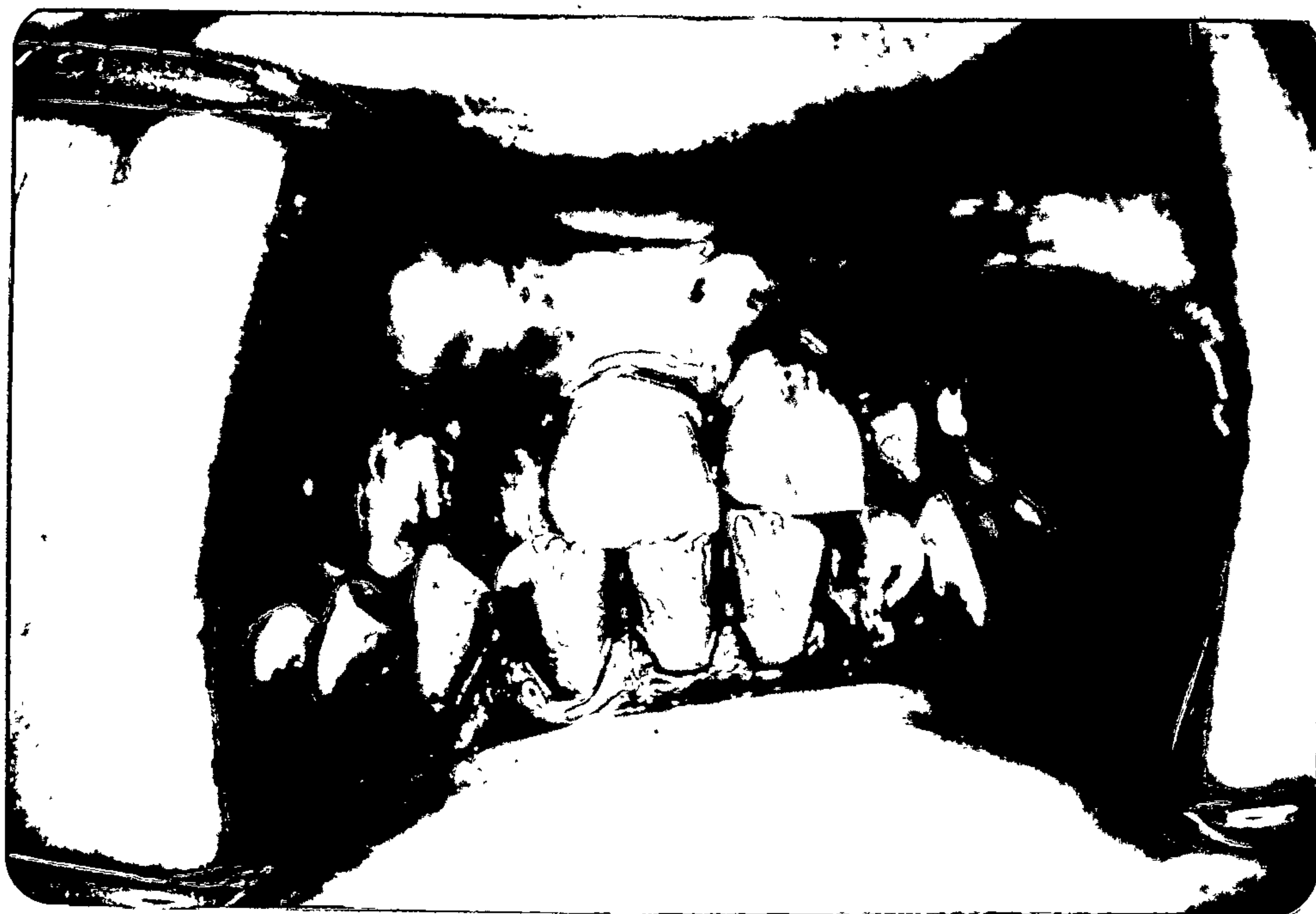


FIG. 12: Colour photographs of stained anterior teeth showing gingival and oral hygiene status at the baseline examination and after three months for a subject showing the effects of poor motivation in oral care.

Subject from Group II - Experimental No Bands.

The results showed no statistically significant differences between the sexes in Plaque Index and Gingival Index scores. In the control group subjects, girls generally showed better hygiene conditions. In the experimental group subjects, final scores indicated more improvement of gingival health in girls than in boys. As suggested by King (1945), hormonal factors may have been responsible for this difference. The author decided against differentiating the sexes into two groups because:-

- a) The average age of the subjects was 15.4 years for boys and 15.0 for girls. (Table 53). This is beyond puberty, the age group in which hormonal influences may have asserted some effect.
- b) To show a statistically significant difference the number of subjects in each group was insufficient.
- c) There was a wide range of ages, (11.2 to 23.7 years), which further reduced the number of subjects of pubertal age, and this may have masked any hormonal influences that may have been present. (Table 53).

The author feels that the superior gingival health displayed by girls may be explained in part by social pressures on cosmetic care related to improvement in oral hygiene, as suggested by Day, (1951).

The present study being only of three-month duration is considered by the author to be a pilot study for future investigation. If supervised plaque control was instigated prior to orthodontic banding and continued perhaps for one year post-retention, the effects on gingival health would be of interest.

Thus the present study might be extended to review post-retention changes in gingival health. A suggested hypothesis that oral hygiene motivation during orthodontic treatment and the orthodontic correction itself may lead to long term self-care and oral health improvement could be tested.

E. CONCLUSION

There is a direct relationship between plaque accumulation and gingival inflammation. This effect is most apparent when fixed orthodontic appliances are worn because of the increased difficulty of adequately removing plaque from these appliances.

Removal of plaque deposits from around orthodontic appliances results in a significant improvement in the gingival health status. In patients receiving professional plaque control every two weeks and having reasonable personal plaque control, the adverse effects of plaque accumulation on the gingiva can be eliminated.

The adverse effects of fixed orthodontic appliances on the gingiva is predominantly a function of their added plaque retaining properties.

F. SUMMARY

Inflammation of the gingivae is a common finding among patients undergoing fixed orthodontic appliance therapy. The purpose of this study was to:-

1. Assess the association of fixed appliances and plaque with gingival inflammation.
2. Determine if this inflammation could be reduced or eliminated by supervised plaque control.

Eighty adolescent and young adult subjects were divided into two equal groups. One group was composed of patients wearing fixed appliances whilst the other group comprised subjects possessing malocclusions and awaiting orthodontic treatment. These two groups were further subdivided into an experimental and a control group.

All subjects were assessed at the baseline examination and after three months for plaque accumulation and gingival status according to the Plaque Index (Silness and Løe, 1963) and Gingival Index (Løe and Silness, 1964) systems. Experimental group subjects were also assessed at two-weekly intervals during which systematic professional plaque control was undertaken and repeated motivation and instruction in toothbrushing with a horizontal scrub technique was given. Emphasis was directed toward the gingival areas. Control group subjects received no toothbrushing instruction or supervised plaque control, but continued their habitual cleaning methods.

At the end of the trial period statistical comparisons were made of the degree of improvement over baseline scores for gingival and plaque conditions for all groups.

The results indicate:-

1. A significant improvement in gingival health when plaque control measures are undertaken ($p < 0.01$).
2. That there is a direct relationship between oral hygiene and gingival health status.
3. The most important factor responsible for gingival inflammation is bacterial plaque, irrespective of the presence of fixed orthodontic appliances.
4. The adverse effect of orthodontic appliances is a function of its added plaque retaining properties and not a mechanical irritant effect.
5. The interproximal areas were more affected than the buccal areas and posterior teeth more than anterior teeth.
6. Gingivitis associated with patients undergoing fixed appliance therapy can be controlled by repeated motivation and supervised plaque control.

A P P E N D I X

TABLES 23 - 38 illustrate Gingival and Plaque Index initial and final scores for the different tooth surfaces and the different locations in the mouth.

TABLES 39 - 52 illustrate the statistical analysis for Gingival and Plaque Indices using the Analysis of Variance.

TABLE 53 shows the mean age of subjects.

FIGURES 13 - 28 illustrate the percentage frequency of Gingival and Plaque Index scores for Groups I, II, III and IV.

TABLE 23.

GINGIVAL INDEX - INITIAL SCORES

INTERPROXIMAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	0	8	4	0	2	10	0	0	3	9	0
2	0	0	10	2	0	2	10	0	0	4	8	0
3	0	0	5	7	0	3	9	0	0	4	8	0
4	0	0	8	4	0	4	8	0	1	4	7	0
5	0	1	6	5	0	4	8	0	0	1	11	0
6	0	2	10	0	2	2	8	0	0	4	8	0
7	0	2	4	6	2	0	10	0	0	4	8	0
8	0	0	12	0	0	3	9	0	0	3	9	0
9	0	0	6	6	2	3	7	0	0	4	8	0
10	0	0	3	9	0	0	12	0	0	4	8	0
FEMALES												
1	0	0	8	4	0	2	10	0	0	5	7	0
2	0	1	11	0	0	6	6	0	0	3	9	0
3	0	1	8	3	0	2	10	0	0	2	10	0
4	0	2	2	8	0	1	11	0	2	6	4	0
5	0	0	12	0	0	5	7	0	0	3	9	0
6	0	1	11	0	0	4	8	0	0	4	8	0
7	0	0	12	0	0	1	11	0	0	5	7	0
8	0	0	8	4	0	0	8	0	0	5	7	0
9	0	0	9	3	1	7	4	0	0	2	10	0
10	0	0	12	0	0	4	8	0	0	4	8	0
	0	10	165	65	7	55	174	4	0	74	163	0

TABLE 24.

GINGIVAL INDEX - FINAL SCORES

INTERPROXIMAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	5	7	0	1	5	6	0	0	1	11	0
2	2	1	9	0	0	4	8	0	0	2	10	0
3	0	4	8	0	0	7	5	0	0	6	6	0
4	0	7	5	0	0	6	6	0	0	7	5	0
5	1	4	7	0	0	10	2	0	0	0	12	0
6	0	6	6	0	0	6	6	0	0	1	11	0
7	0	7	5	0	0	6	6	0	0	1	11	0
8	2	3	7	0	1	8	3	0	0	4	8	0
9	0	5	7	0	3	5	4	0	0	3	9	0
10	0	6	6	0	0	2	10	0	0	2	10	0
FEMALES												
1	0	6	5	1	2	5	5	0	0	4	8	0
2	4	6	2	0	4	6	2	0	0	4	8	0
3	0	4	8	0	5	0	7	0	0	4	8	0
4	0	4	8	0	0	5	7	0	2	4	6	0
5	0	5	7	0	2	7	3	0	0	2	10	0
6	2	4	6	0	4	6	2	0	0	3	9	0
7	0	8	4	0	0	6	6	0	0	8	4	0
8	0	6	6	0	0	1	11	0	0	4	8	0
9	1	5	6	0	4	5	3	0	0	1	11	0
10	0	6	6	0	4	6	2	0	0	1	11	0
	12	102	125	1	30	106	104	0	0	62	176	0

TABLE 25.

GINGIVAL INDEX - INITIAL SCORES

FACIAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	6	5	1	1	9	2	0	0	5	6	0
2	0	5	7	0	1	7	4	0	0	8	4	0
3	0	4	6	2	7	7	4	0	10	2	0	0
4	1	7	4	0	2	8	2	0	1	8	3	0
5	1	5	5	1	0	11	1	0	0	4	8	0
6	0	7	5	0	3	7	2	0	3	5	4	0
7	0	5	6	1	4	5	3	0	2	6	4	0
8	0	4	8	0	4	6	2	0	0	7	5	0
9	0	4	6	2	8	2	2	0	0	9	3	0
10	1	4	6	1	0	4	8	0	2	5	5	0
FEMALES												
1	0	6	6	0	3	7	2	0	0	9	3	0
2	1	7	4	0	5	3	4	0	2	5	5	0
3	0	6	6	0	4	7	1	0	0	9	3	0
4	0	5	7	0	1	7	4	0	5	4	3	0
5	0	5	7	0	0	12	0	0	0	6	6	0
6	0	4	8	0	2	8	2	0	0	8	4	0
7	1	5	6	0	0	7	5	0	3	9	0	0
8	0	5	6	1	0	2	10	0	3	3	6	0
9	1	6	5	0	7	4	1	0	0	6	6	0
10	1	5	6	0	2	7	3	0	1	5	6	0
	7	105	119	9	48	130	62	0	11	104	118	7
	33	123	84	0								

TABLE 26.

GINGIVAL INDEX - FINAL SCORES

FACIAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3

INDEX NO. OF SUBJECT	GROUP I (EB)				GROUP II (ENB)				GROUP III (CB)				GROUP IV (CNB)			
	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
MALES																
1	7	2	3	0	3	7	2	0	0	4	8	0	5	7	0	0
2	4	8	0	0	4	6	2	0	0	4	8	0	3	4	5	0
3	2	6	4	0	2	10	0	0	0	5	7	0	6	6	0	0
4	4	7	1	0	7	5	0	0	0	7	5	0	4	4	4	0
5	3	8	1	0	6	5	1	0	0	8	4	0	0	4	8	0
6	3	9	0	0	8	3	1	0	0	4	8	0	1	9	2	0
7	4	6	2	0	6	5	1	0	0	1	10	0	0	8	4	0
8	5	6	1	0	8	4	0	0	0	6	5	1	0	11	1	0
9	5	5	2	0	10	2	0	0	0	3	8	1	3	7	2	0
10	5	4	3	0	0	9	3	0	0	4	8	0	1	8	3	0
FEMALES																
1	4	4	4	0	6	6	0	0	1	3	7	1	0	12	0	0
2	5	5	2	0	7	5	0	0	2	5	5	0	1	8	3	0
3	4	8	0	0	5	7	0	0	0	6	6	0	1	5	6	0
4	5	5	2	0	6	3	3	0	0	5	5	2	3	7	2	0
5	1	9	2	0	4	7	1	0	0	6	6	0	1	6	5	0
6	7	3	2	0	8	2	2	0	1	1	10	0	0	7	5	0
7	4	6	2	0	2	7	3	0	1	4	6	1	2	8	2	0
8	3	5	4	0	0	7	5	0	0	8	4	0	1	5	6	0
9	6	6	0	0	8	4	0	0	0	6	6	0	1	7	4	0
10	5	7	0	0	8	2	2	0	0	6	6	0	2	7	3	0
	86	119	35	0	108	106	26	0	6	96	132	6	35	140	65	0

TABLE 27.

PLAQUE INDEX - INITIAL SCORES

INTERPROXIMAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	3	9	0	0	5	7	0	0	2	8	0
2	0	1	11	0	0	4	8	0	0	0	6	0
3	0	1	9	2	0	5	7	0	1	7	4	0
4	0	3	9	0	0	5	7	0	1	5	6	0
5	0	2	8	2	0	7	5	0	0	1	11	0
6	0	4	8	0	0	5	7	0	1	4	7	0
7	0	3	7	2	1	4	7	0	0	5	7	0
8	0	3	9	0	1	8	3	0	0	3	9	0
9	0	2	6	4	2	6	4	0	0	5	7	0
10	0	3	9	0	0	1	11	0	0	4	8	0
FEMALES												
1	0	3	9	0	0	3	9	0	0	7	5	0
2	0	6	6	0	0	8	4	0	0	5	7	0
3	0	3	9	0	1	4	7	0	0	3	9	0
4	0	3	9	0	1	3	8	0	2	8	2	0
5	0	2	10	0	0	7	5	0	0	4	8	0
6	0	2	10	0	1	5	6	0	0	7	5	0
7	0	2	10	0	0	2	10	0	0	7	5	0
8	0	5	6	1	0	0	5	0	4	1	7	0
9	0	4	8	0	3	7	2	0	0	3	9	0
10	0	4	8	0	2	6	4	0	0	8	4	0
	0	59	170	11	12	95	126	7	11	95	134	0

TABLE 28.

PLAQUE INDEX - FINAL SCORES

INTERPROXIMAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	7	5	0	2	8	2	0	0	1	5	0
2	2	5	5	0	2	6	4	0	0	0	4	0
3	0	5	7	0	0	8	4	0	0	2	7	0
4	3	6	3	0	2	8	2	0	0	0	3	0
5	2	8	2	0	5	6	1	0	0	0	6	0
6	2	8	2	0	6	2	4	0	0	0	12	0
7	2	7	3	0	9	1	2	0	0	0	6	0
8	3	7	2	0	3	7	2	0	0	0	8	0
9	1	6	5	0	7	3	2	0	0	9	9	0
10	1	6	5	0	0	4	8	0	0	0	6	0

TABLE 29.

PLAQUE INDEX - INITIAL SCORES

FACIAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	3	5	4	0	4	7	1	0	2	5	0	0
2	3	6	3	0	2	8	2	0	0	9	2	0
3	1	5	5	1	3	8	1	0	4	4	0	0
4	1	8	3	0	6	6	0	0	2	10	0	0
5	2	9	1	0	3	8	1	0	0	6	2	0
6	0	11	1	0	4	6	2	0	0	6	5	0
7	0	11	1	0	5	5	2	0	2	9	0	0
8	0	8	4	0	4	8	0	0	0	9	1	0
9	0	8	3	1	9	2	1	0	2	6	2	0
10	1	8	2	1	0	7	5	0	1	9	2	0
FEMALES												
1	1	8	3	0	1	11	0	0	1	8	0	0
2	2	7	3	0	5	5	2	0	1	7	2	0
3	0	10	2	0	7	3	2	0	5	9	1	0
4	1	6	5	0	7	2	3	0	3	6	0	0
5	2	8	2	0	3	8	1	0	2	6	4	0
6	0	10	2	0	6	5	1	0	0	8	3	0
7	0	10	2	0	2	8	2	0	2	9	0	0
8	1	7	3	1	6	2	8	0	3	1	6	0
9	0	8	4	0	8	4	0	0	2	5	5	0
10	5	5	2	0	2	6	4	0	7	6	5	0
	23	158	55	4	81	119	38	2	39	144	55	2
									62	133	45	0

TABLE 30.

PLAQUE INDEX - FINAL SCORES

FACIAL SURFACES - 12 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP 1 (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	7	4	1	0	7	4	1	0	12	0	0	0
2	8	4	0	0	7	4	1	0	1	9	2	0
3	2	8	2	0	4	8	0	0	11	1	0	0
4	8	4	0	0	10	2	0	0	1	8	3	0
5	7	5	0	0	10	2	0	0	2	4	6	0
6	9	3	0	0	10	2	0	0	5	7	0	0
7	5	7	0	0	10	2	0	0	0	10	2	0
8	9	3	0	0	10	2	0	0	0	10	2	0
9	5	7	0	0	12	0	0	0	1	9	2	0
10	7	4	1	0	7	5	0	0	2	8	2	0
FEMALES												
1	5	5	2	0	7	5	0	0	2	10	0	0
2	9	3	0	0	10	2	0	0	1	10	1	0
3	4	8	0	0	7	5	0	0	1	8	3	0
4	5	6	1	0	6	6	0	0	3	9	0	0
5	3	8	1	0	8	4	0	0	1	8	3	0
6	7	6	1	0	9	3	0	0	3	6	3	0
7	5	6	1	0	5	6	0	0	6	6	0	0
8	6	6	0	0	0	7	0	0	4	4	4	0
9	8	4	0	0	11	1	0	0	2	5	5	0
10	6	6	0	0	8	4	0	0	3	8	1	0
	125	105	10	0	158	74	8	0	61	140	39	0

TABLE 31.

GINGIVAL INDEX - INITIAL SCORES

ANTERIOR TEETH - 8 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	4	4	0	1	5	2	0	0	1	6	0
2	0	3	5	0	1	5	2	0	0	0	5	0
3	0	4	2	2	1	6	1	0	3	4	1	0
4	1	3	4	0	0	6	5	0	2	5	1	0
5	1	4	3	0	0	6	3	0	0	4	1	0
6	0	6	2	0	2	3	2	0	1	7	0	0
7	0	5	1	2	4	2	3	0	1	7	0	0
8	0	2	6	0	3	2	4	0	0	4	4	0
9	0	3	5	0	5	1	4	0	0	5	3	0
10	1	3	2	2	0	0	6	0	2	6	0	0
FEMALES												
1	0	3	5	0	2	4	2	0	0	4	4	0
2	1	1	6	0	4	4	0	0	0	7	1	0
3	0	5	3	0	3	3	2	0	0	4	4	0
4	0	6	0	2	0	8	5	0	5	3	0	0
5	0	4	4	0	2	4	5	0	0	7	1	0
6	0	5	3	0	0	2	5	0	0	8	0	0
7	1	3	4	0	2	2	2	0	0	3	5	0
8	0	4	4	0	0	2	0	2	5	3	0	0
9	1	2	4	1	4	4	5	0	0	5	3	0
10	0	2	6	0	2	6	4	0	1	7	0	0
	6	72	73	9	34	76	49	1	11	63	81	5
	21	104	35	0								

TABLE 32.

GINGIVAL INDEX - FINAL SCORES

ANTERIOR TEETH - 8 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	4	4	0	0	4	4	0	0	0	3	2	0
2	4	3	1	0	1	5	2	0	0	3	3	0
3	2	2	4	0	1	6	1	0	0	2	2	0
4	3	4	1	0	4	3	1	0	0	3	2	0
5	4	3	1	0	3	5	0	0	0	0	0	0
6	2	6	0	0	4	4	0	0	0	2	6	0
7	3	5	0	0	3	3	2	0	0	0	3	0
8	6	2	0	0	4	4	0	0	0	0	1	0
9	3	3	2	0	7	1	0	0	2	4	2	0
10	3	5	0	0	0	6	2	0	1	5	2	0
FEMALES												
1	2	4	2	0	6	2	0	0	0	7	1	0
2	6	2	0	0	8	0	0	0	1	7	0	0
3	1	6	1	0	6	2	0	0	0	0	8	0
4	2	6	0	0	4	4	0	0	4	4	0	0
5	1	7	0	0	4	4	0	0	0	6	2	0
6	6	2	0	0	8	0	0	0	0	7	1	0
7	3	5	0	0	0	3	5	0	0	2	6	0
8	3	5	0	0	0	3	5	0	1	7	0	0
9	4	4	0	0	8	0	0	0	1	4	3	0
10	3	5	0	0	6	2	0	0	1	4	3	0
	65	83	12	0	81	61	18	0	6	63	85	6
									22	88	50	0

TABLE 33.

GINGIVAL INDEX - INITIAL SCORES

POSTERIOR TEETH - 16 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	0	2	9	5	0	6	10	0	0	2	14	0
2	0	2	12	2	0	4	12	0	0	6	10	0
3	0	0	9	7	0	4	12	0	7	2	7	0
4	0	4	8	4	2	6	8	0	0	7	9	0
5	0	2	8	6	0	9	7	0	0	1	15	0
6	0	3	13	0	3	6	7	0	2	2	12	0
7	0	2	9	5	2	3	11	0	1	3	12	0
8	0	2	14	0	2	7	7	0	0	6	10	0
9	0	1	7	8	5	4	7	0	0	8	8	0
10	0	1	7	8	0	4	12	0	0	3	13	0
FEMALES												
1	0	3	9	4	1	5	10	0	0	10	6	0
2	0	7	9	0	1	5	10	0	2	2	12	0
3	0	2	11	3	1	5	10	0	0	7	9	0
4	0	1	9	6	1	5	10	0	3	7	6	0
5	0	1	15	0	9	9	7	0	0	2	14	0
6	0	0	16	0	8	8	8	0	0	4	12	0
7	0	2	14	0	6	10	13	0	2	10	4	0
8	0	1	10	5	0	0	5	0	0	3	13	0
9	0	4	10	2	4	7	5	0	0	3	13	0
10	1	3	12	0	0	5	11	0	0	2	14	0
	1	43	211	65	22	108	187	3	0	57	192	71
									17	90	213	0

TABLE 34.

GINGIVAL INDEX - FINAL SCORES

POSTERIOR TEETH - 16 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	3	3	10	0	2	8	6	0	0	2	8	0
2	2	6	8	0	3	5	8	0	0	0	13	0
3	0	8	8	0	1	11	4	0	0	4	4	0
4	1	10	5	0	3	8	5	0	1	6	9	0
5	0	9	7	0	3	10	3	0	0	2	14	0
6	1	9	6	0	6	5	5	0	1	5	10	0
7	1	8	7	0	3	11	2	0	0	6	10	0
8	1	7	8	0	5	8	3	0	0	8	8	0
9	2	7	7	0	6	6	4	0	1	6	9	0
10	2	5	9	0	0	5	11	0	0	5	11	0
FEMALES												
1	2	6	7	1	2	9	5	0	0	9	7	0
2	3	9	4	0	3	11	2	0	0	5	11	0
3	3	6	7	0	4	5	7	0	1	9	6	0
4	3	3	10	0	2	4	10	0	1	7	8	0
5	0	7	9	0	2	10	4	0	1	2	13	0
6	3	5	8	0	4	8	4	0	0	3	13	0
7	1	9	6	0	2	10	4	0	2	14	0	0
8	0	6	10	0	0	5	11	0	0	2	14	0
9	3	7	6	0	4	9	3	0	0	4	12	0
10	2	8	6	0	6	6	4	0	1	4	11	0
	33	138	148	1	61	154	105	0	0	15	114	191
						50	198	72				0

TABLE 35.

PLAQUE INDEX - INITIAL SCORE

ANTERIOR TEETH - 8 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	2	4	2	0	3	5	0	0	1	3	2	0
2	3	2	3	0	2	6	0	0	0	4	2	0
3	1	4	3	0	3	4	1	0	2	2	2	0
4	1	4	3	0	3	3	2	0	1	2	1	0
5	2	4	2	0	1	6	1	0	0	6	0	0
6	0	7	1	0	2	6	0	0	0	4	3	0
7	0	5	3	0	4	3	1	0	2	6	0	0
8	0	7	1	0	3	5	0	0	0	7	0	0
9	0	5	3	0	4	4	0	0	2	4	2	0
10	1	6	1	0	0	2	6	0	0	7	0	0
FEMALES												
1	1	5	2	0	1	5	2	0	1	4	2	0
2	2	6	0	0	4	4	0	0	0	5	1	0
3	0	5	3	0	5	1	2	0	1	3	4	0
4	1	5	2	0	3	2	3	0	6	2	0	0
5	1	5	2	0	3	5	0	0	2	5	1	0
6	0	4	4	0	4	4	0	0	0	7	4	0
7	0	6	2	0	0	6	3	0	2	4	0	0
8	1	7	0	0	0	2	0	0	7	1	1	0
9	0	7	1	0	6	2	4	0	2	5	0	0
10	4	2	2	0	3	5	2	0	3	7	0	0
20	100	40	0	0	54	80	25	1	28	87	43	2
									46	88	26	0

TABLE 36.

PLAQUE INDEX - FINAL SCORE

ANTERIOR TEETH - 8 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	4	4	0	0	6	2	0	0	0	5	2	0
2	6	2	0	0	3	5	0	0	0	1	6	0
3	2	3	3	0	3	3	2	0	1	5	1	0
4	6	2	0	0	5	3	0	0	0	1	0	0
5	4	4	0	0	6	2	0	0	0	0	0	0
6	5	3	0	0	7	1	0	0	2	1	7	0
7	4	4	0	0	6	2	0	0	0	5	1	0
8	6	2	0	0	5	3	0	0	0	7	1	0
9	3	4	1	0	8	0	0	0	0	5	3	0
10	5	3	0	0	2	6	0	0	2	6	2	0
FEMALES												
1	4	4	0	0	8	0	0	0	1	5	2	0
2	6	2	0	0	8	0	0	0	1	7	0	0
3	4	2	2	0	7	1	0	0	0	1	7	0
4	3	3	2	0	5	3	0	0	3	5	0	0
5	3	5	0	0	5	3	0	0	1	5	2	0
6	5	3	0	0	7	1	0	0	1	7	0	0
7	1	7	0	0	3	4	2	0	1	3	4	0
8	6	2	0	0	0	4	2	0	1	3	0	0
9	7	1	0	0	8	0	0	0	5	6	0	0
10	5	3	0	0	8	0	0	0	2	6	0	0
	89	63	8	0	110	42	8	0	27	79	54	0
									33	96	31	0

TABLE 37.

PLAQUE INDEX - INITIAL SCORE

POSTERIOR TEETH - 16 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES												
1	1	4	11	0	1	7	8	0	1	5	10	0
2	0	6	10	0	0	6	10	0	0	7	9	0
3	0	2	11	3	0	9	7	0	1	2	10	3
4	0	8	8	0	3	8	5	0	1	7	3	0
5	0	7	6	3	2	9	5	0	0	8	13	0
6	0	8	8	0	2	5	9	0	0	7	7	0
7	0	9	5	2	2	6	8	0	1	7	8	0
8	0	4	12	0	2	11	3	0	0	8	8	0
9	0	5	6	5	7	4	5	0	0	7	7	0
10	0	5	10	1	0	6	10	0	1	6	10	0
FEMALES												
1	0	6	10	0	0	9	7	0	2	11	3	0
2	0	7	9	0	1	9	6	0	1	7	8	0
3	0	8	8	0	4	6	6	0	3	9	6	0
4	0	4	12	0	4	3	9	0	2	12	2	0
5	1	5	10	0	0	10	6	0	0	5	11	0
6	0	8	8	0	3	6	7	0	0	8	8	0
7	0	6	10	0	2	4	10	0	3	12	1	0
8	0	5	9	2	0	0	8	5	2	1	13	0
9	0	5	11	0	5	9	2	0	0	3	13	0
10	1	7	8	0	1	7	8	0	0	7	9	0
	3	119	182	16	39	134	139	8	12	116	163	29
									27	140	153	0

TABLE 38.

PLAQUE INDEX - FINAL SCORE

POSTERIOR TEETH - 16 SURFACES - NUMBERS OF SCORE 0, 1, 2, 3.

INDEX NO. OF SUBJECT	GROUP I (EB)			GROUP II (ENB)			GROUP III (CB)			GROUP IV (CNB)		
	0	1	2	3	0	1	2	3	0	1	2	3
MALES :												
1	3	7	6	0	3	10	3	0	8	3	5	0
2	3	7	6	0	6	5	5	0	0	7	9	0
3	0	11	5	0	1	13	11	0	8	5	3	0
4	5	8	3	0	7	7	7	0	0	7	9	0
5	5	9	2	0	9	6	5	0	2	3	11	0
6	6	8	2	0	9	3	6	0	3	8	5	0
7	3	10	3	0	13	1	8	0	0	7	9	0
8	6	8	2	0	8	6	6	0	0	8	8	0
9	3	8	5	0	11	3	11	0	1	9	6	0
10	3	7	6	0	5	3	11	0	0	9	7	0
FEMALES												
1	2	8	6	0	3	11	9	3	2	12	2	0
2	8	8	0	0	7	9	9	0	0	8	8	0
3	2	12	2	0	5	10	5	3	1	9	6	0
4	3	8	5	0	4	6	9	0	0	12	4	0
5	0	12	4	0	7	7	9	0	0	7	9	0
6	2	10	4	0	8	6	9	3	2	5	9	0
7	5	8	3	0	4	7	9	1	5	11	0	0
8	2	10	4	0	0	6	5	0	0	4	12	0
9	5	7	4	0	8	8	11	0	0	3	13	0
10	3	11	2	0	4	10	8	0	1	8	7	0
	69	177	74	0	122	137	165	29	33	145	142	0

TABLE 39.GINGIVAL INDEX - INITIAL SCORESANALYSIS OF VARIANCE

Source of Variation	DF	SS	MS	VR	P
Sex (S)	1	0.01073	0.01073	0.651	NS
Bands (B)	1	1.17871	1.17871	71.523	< 0.01
Group (G)	1	0.00008	0.00008	0.005	NS
S x B	1	0.00327	0.00327	0.198	NS
S x G	1	0.00384	0.00384	0.233	NS
B x G	1	0.00148	0.00148	0.090	NS
S x B x G	1	0.00001	0.00001	0.000	NS
Residual	72	1.18657	0.01648		
Total	79	2.38469	0.03019		

For tables 39 - 50 :-

DF = Degrees of freedom

SS = Sum of squares

MS = Mean square

VR = Variance ratio

P = Probability

TABLE 40

GINGIVAL INDEX - FINAL SCORESANALYSIS OF VARIANCE - ADJUSTED FOR COVARIATES -ARC SINE TRANSFORMATIONS G(0,1)

Source of Variation	DF	SS	MS	VR	P
Sex (S)	1	0.000265	0.000265	0.063	NS
Bands (B)	1	0.003081	0.003081	0.732	NS
Group (G)	1	0.198618	0.198618	47.196	< 0.01
S x B	1	0.000508	0.000508	0.121	NS
S x G	1	0.000000	0.000000	0.000	NS
B x G	1	0.087769	0.087769	20.856	< 0.01
S x B x G	1	0.000036	0.000036	0.008	NS
Covariates	2	1.046562	0.523281	124.344	
Residual	70	0.294584	0.004208		
Total	79	1.631423	0.020651		

TABLE 41.

PLAQUE INDEX - INITIAL SCORES

ANALYSIS OF VARIANCE

Source of Variation	DF	SS	MS	VR	P
Sex (S)	1	0.00313	0.00313	0.144	NS
Bands (B)	1	0.37786	0.37786	17.352	< 0.01
Group (G)	1	0.00031	0.00031	0.014	NS
S x B	1	0.00957	0.00957	0.440	NS
S x G	1	0.00900	0.00900	0.413	NS
B x G	1	0.00159	0.00159	0.073	NS
S x B x G	1	0.00553	0.00553	0.254	NS
Residual	72	1.56792	0.02178		
Total	79	1.97491	0.02500		

TABLE 42.

PLAQUE INDEX - FINAL SCORES

ANALYSIS OF VARIANCE - ADJUSTED FOR COVARIATES -

ARC SINE TRANSFORMATIONS G(0,1)

Source of Variation	DF	SS	MS	VR	P
Sex (S)	1	0.008804	0.008804	1.206	NS
Bands (B)	1	0.004515	0.004515	0.618	NS
Group (G)	1	2.276411	2.276411	311.818	< 0.001
S x B	1	0.005286	0.005286	0.724	NS
S x G	1	0.011820	0.011820	1.619	NS
B x G	1	0.090038	0.090038	12.333	< 0.01
S x B x G	1	0.004058	0.004058	0.556	NS
Covariates	1	1.306389	1.306389	178.947	
Residual	71	0.518331	0.007300		
Total	79	4.225651	0.053489		

TABLE 43.GINGIVAL INDEX - INITIAL SCORESANALYSIS OF VARIANCE - BAND LOCATION -FACIAL AND INTERPROXIMAL SURFACES

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	11.0224	11.0224	55.119	< 0.01
Group (G)	1	0.0001	0.0001	0.001	NS
Face (F)	1	31.3672	31.3672	156.857	< 0.001
B x G	1	0.0392	0.0392	0.196	NS
B x F	1	1.0245	1.0245	5.123	NS
G x F	1	0.0632	0.0632	0.316	NS
B x G x F	1	0.0477	0.0477	0.239	NS
Residual	312	62.3917	0.2000		
Total	319	105.9560			

TABLE 44.

GINGIVAL INDEX - FINAL SCORESANALYSIS OF VARIANCE - ADJUSTED FOR COVARIATES -ARC SINE TRANSFORMATIONS $G(0,1)$ - BAND LOCATION -FACIAL AND INTERPROXIMAL SURFACES

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	0.1744	0.1744	1.546	NS
Group (G)	1	21.9183	21.9183	194.258	< 0.001
Face (F)	1	2.2449	2.2449	19.896	< 0.01
B x G	1	1.7676	1.7676	15.666	< 0.01
B x F	1	0.2112	0.2112	1.872	NS
G x F	1	1.6501	1.6501	14.624	< 0.01
B x G x F	1	0.0718	0.0718	9.636	NS
Covariates	1	15.4149	15.4149	136.620	
Residual	311	35.0903	0.1128		
Total	319	78.5435	0.2462		

TABLE 45.

PLAQUE INDEX - INITIAL SCORES

ANALYSIS OF VARIANCE - BAND LOCATION -
FACIAL AND INTERPROXIMAL SURFACES

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	2.6550	2.6550	15.191	< 0.01
Group (G)	1	0.0076	0.0076	0.044	NS
Face (F)	1	26.2763	26.2763	150.349	< 0.001
B x G	1	0.0182	0.0182	0.104	NS
B x F	1	0.8861	0.8861	5.070	NS
G x F	1	0.0092	0.0092	0.053	NS
B x G x F	1	0.0116	0.0116	0.066	NS
Residual	312	54.5279	0.1748		
Total	319	84.3910	0.2646		

TABLE 46.

PLAQUE INDEX - FINAL SCORESANALYSIS OF VARIANCE - ADJUSTED FOR COVARIATES -ARC SINE TRANSFORMATIONS G(0,1) - BAND LOCATION -FACIAL AND INTERPROXIMAL SURFACES

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	0.09993	0.09993	1.231	NS
Group (G)	1	11.47692	11.47692	141.319	< 0.001
Face (F)	1	1.52013	1.52013	18.718	< 0.001
B x G	1	0.71087	0.71087	8.753	< 0.01
B x F	1	0.11819	0.11819	1.455	NS
G x F	1	2.08088	2.08088	25.623	< 0.01
B x G x F	1	0.32834	0.32834	4.043	NS
Covariates	1	15.64455	15.64455	192.637	
Residual	311	25.25715	0.08121		
Total	319	57.23696	0.17943		

TABLE 47.

GINGIVAL INDEX - INITIAL SCORES

ANALYSIS OF VARIANCE - BAND POSITION

ANTERIOR AND POSTERIOR

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	11.0224	11.0224	46.509	< 0.01
Group (G)	1	0.0001	0.0001	0.001	NS
Position (P)	1	20.4030	20.4030	86.091	< 0.01
B x G	1	0.0103	0.0103	0.043	NS
B x P	1	0.3282	0.3282	1.385	NS
G x P	1	0.0181	0.0181	0.077	NS
B x G x P	1	0.2322	0.2322	0.980	NS
Residual	312	73.9417	0.2370		
Total	319	105.9560	0.3322		

TABLE 48.

GINGIVAL INDEX - FINAL SCORES

ANALYSIS OF VARIANCE - ADJUSTED FOR COVARIATES -
ARC SINE TRANSFORMATIONS $G(0,1)$ - BAND POSITION -
ANTERIOR AND POSTERIOR

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	0.1016	0.1016	0.854	NS
Group (G)	1	21.9219	21.9219	184.412	< 0.001
Position (P)	1	1.5767	1.5767	13.264	< 0.01
B x G	1	1.8378	1.8378	15.460	< 0.01
B x P	1	0.3158	0.3158	2.657	NS
G x P	1	0.4030	0.4030	3.390	NS
B x G x P	1	0.1186	0.1186	0.997	NS
Covariates	1	20.8177	20.8177	175.123	
Residual	311	36.9700	0.1189		
Total	319	84.0632	0.2635		

TABLE 49.PLAQUE INDEX - INITIAL SCORESANALYSIS OF VARIANCE - BAND POSITION -
ANTERIOR AND POSTERIOR

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	2.6550	2.6550	13.568	< 0.01
Group (G)	11	0.0076	0.0076	0.039	NS
Position (P)	1	20.4961	20.4961	104.746	< 0.001
B x G	1	0.0013	0.0013	0.007	NS
B x P	1	0.1482	0.1482	0.757	NS
G x P	1	0.0054	0.0054	0.027	NS
B x G x P	1	0.0282	0.0282	0.144	NS
Residual	312	61.0502	0.1957		
Total	319	84.3919	0.2646		

TABLE 50.PLAQUE INDEX - FINAL SCORESANALYSIS OF VARIANCE - ADJUSTED FOR COVARIATES -ARC SINE TRANSFORMATIONS G(0,1) - BAND POSITION -ANTERIOR AND POSTERIOR

Source of Variation	DF	SS	MS	VR	P
Bands (B)	1	0.02890	0.02890	0.310	NS
Group (G)	1	11.42268	11.42268	122.640	< 0.001
Position (P)	1	0.01759	0.01759	0.189	NS
B x G	1	0.74794	0.74794	8.030	< 0.05
B x P	1	0.00307	0.00307	0.033	NS
G x P	1	0.20406	0.20406	2.191	NS
B x G x P	1	0.00002	0.00002	0.000	NS
Covariates	1	24.05693	258.288		
Residual	311	28.96647	0.09314		
Total	319	65.44767	0.20517		

TABLE 51.GINGIVAL INDEXSIGNIFICANCE TESTS (Student's "t" test)Tests on Difference of the Means

A. Initial Scores - Between Groups

	t	P
Group I (EB) - Group II (ENB)	4.53	< 0.01
Group I (EB) - Group III (CB)	0.25	N.S.
Group II (ENB) - Group IV (CNB)	0.36	N.S.
Group III (CB) - Group IV (CNB)	4.06	< 0.01

B. Final Scores - Between Groups

	t	P
Group I (EB) - Group II (ENB)	1.47	N.S.
Group I (EB) - Group III (CB)	9.00	< 0.01
Group II (ENB) - Group IV (CNB)	4.86	< 0.01
Group III (CB) - Group IV (CNB)	4.61	< 0.01

TABLE 52.

PLAQUE INDEXSIGNIFICANCE TESTS (Student's "t" test)Tests on Differences of the Means

A. Initial Scores - Between Groups

	t	P
Group I (EB) - Group II (ENB)	2.35	< .05
Group I (EB) - Group III (CB)	0.06	N.S.
Group II (ENB) - Group IV (CNB)	0.24	N.S.
Group III (CB) - Group IV (CNB)	2.15	< 0.05

B. Final Scores - Between Groups

	t	P
Group I (EB) - Group II (ENB)	0.76	N.S.
Group I (EB) - Group III (CB)	6.9	< 0.01
Group II (ENB) - Group IV (CNB)	4.35	< 0.01
Group III (CB) - Group IV (CNB)	2.71	< 0.05

TABLE 53.

AGE OF SUBJECTS IN YEARS - GROUPS I, II, III, IV.

	<u>GROUP I</u>	<u>GROUP II</u>	<u>GROUP III</u>	<u>GROUP IV.</u>
MEAN AGE - MALES	16.0	14.9	15.7	14.7
MEAN AGE - FEMALES	15.5	14.6	15.5	14.3
MEAN AGE OF GROUP	15.78	14.73	15.64	14.49
RANGE	11.9 - 23.7	11.2 - 17.5	12.6 - 22.0	12.4 - 18.3
TOTAL MEAN - ALL SUBJECTS	15.17 Years			
TOTAL RANGE - ALL SUBJECTS	11.2 - 23.7			
MEAN - GROUP I AND GROUP III (BANDS)	15.71			
MEAN - GROUP II AND GROUP IV (NO BANDS)	14.61			
MEAN - GROUP I AND GROUP II (EXPERIMENTAL)	15.26			
MEAN - GROUP III AND GROUP IV (CONTROL)	15.07			
MEAN - MALES	15.36			
MEAN - FEMALES	14.98			

FIG. 13.

PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
GROUP I (EB)

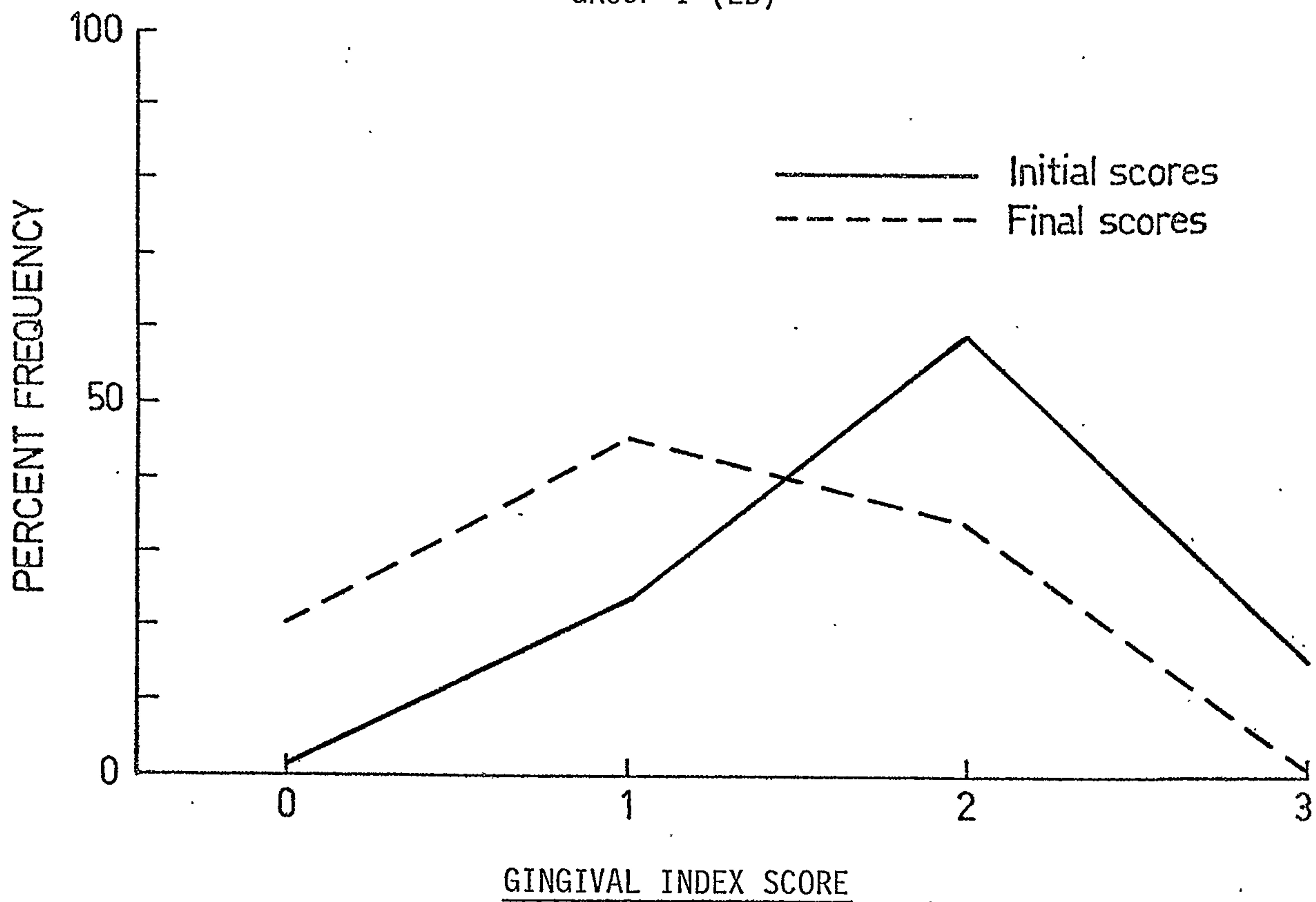


FIG. 14.

PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
GROUP II (ENB)

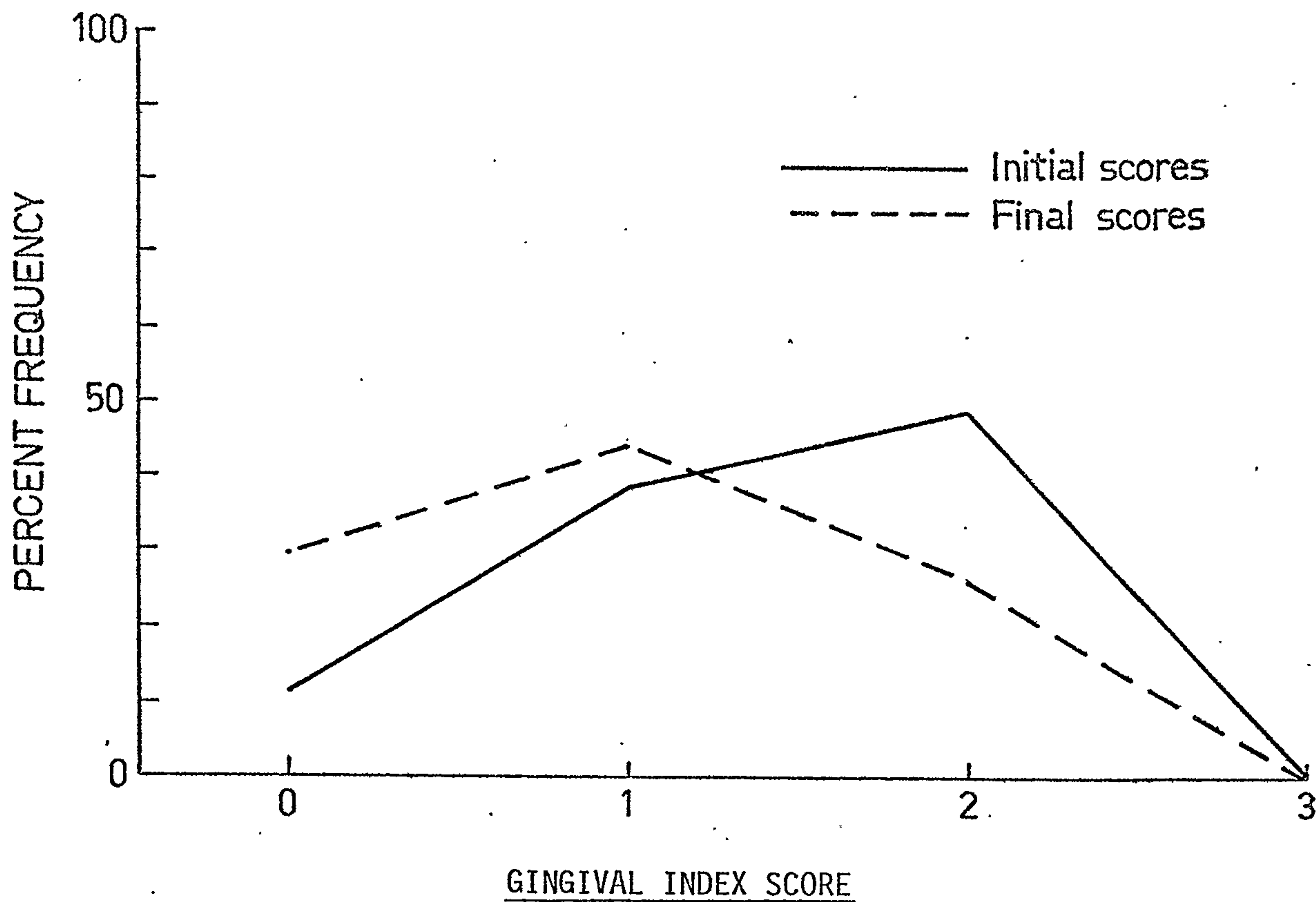


FIG. 15.

PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
GROUP III (CB)

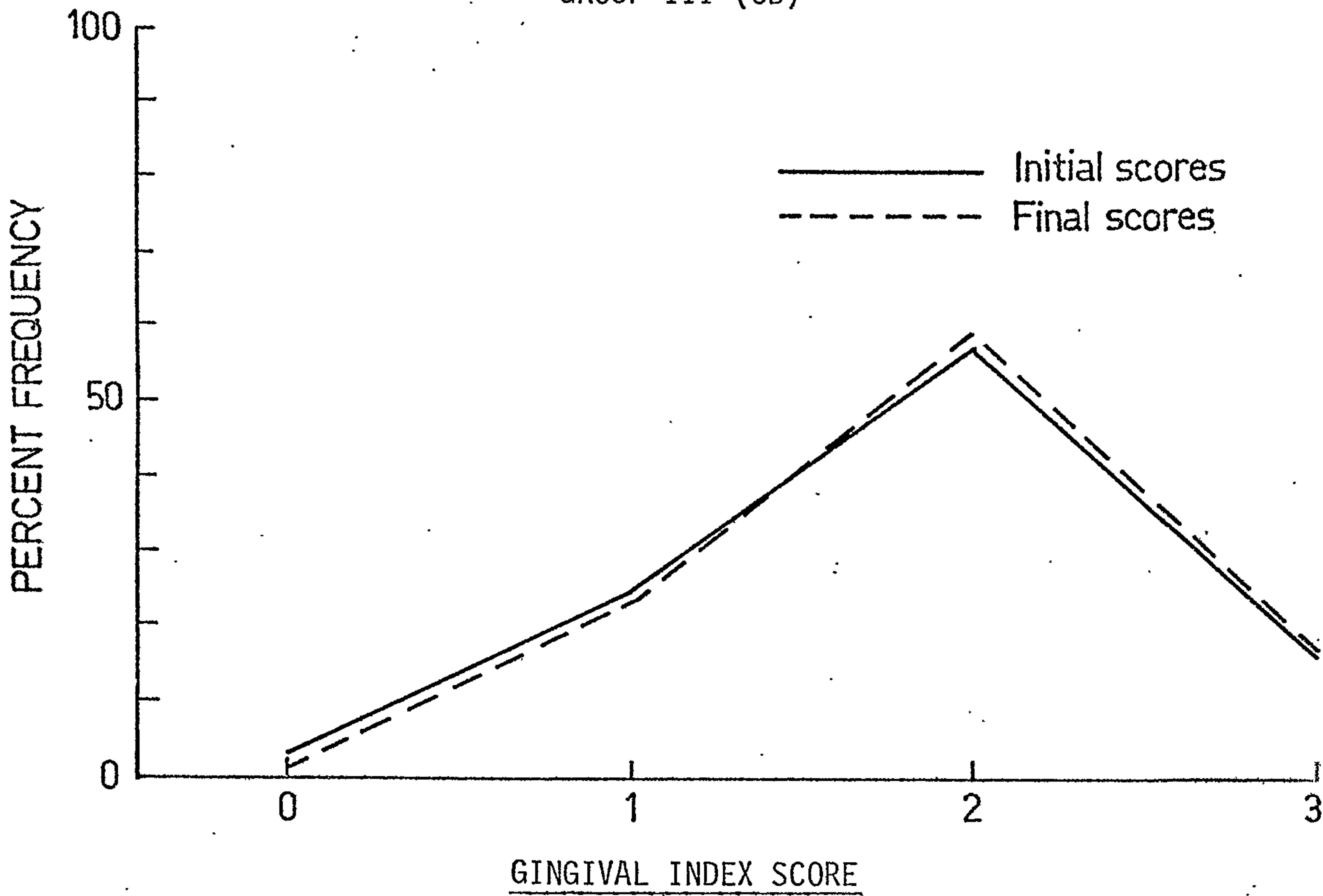


FIG. 16.

PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
GROUP IV (CNB)

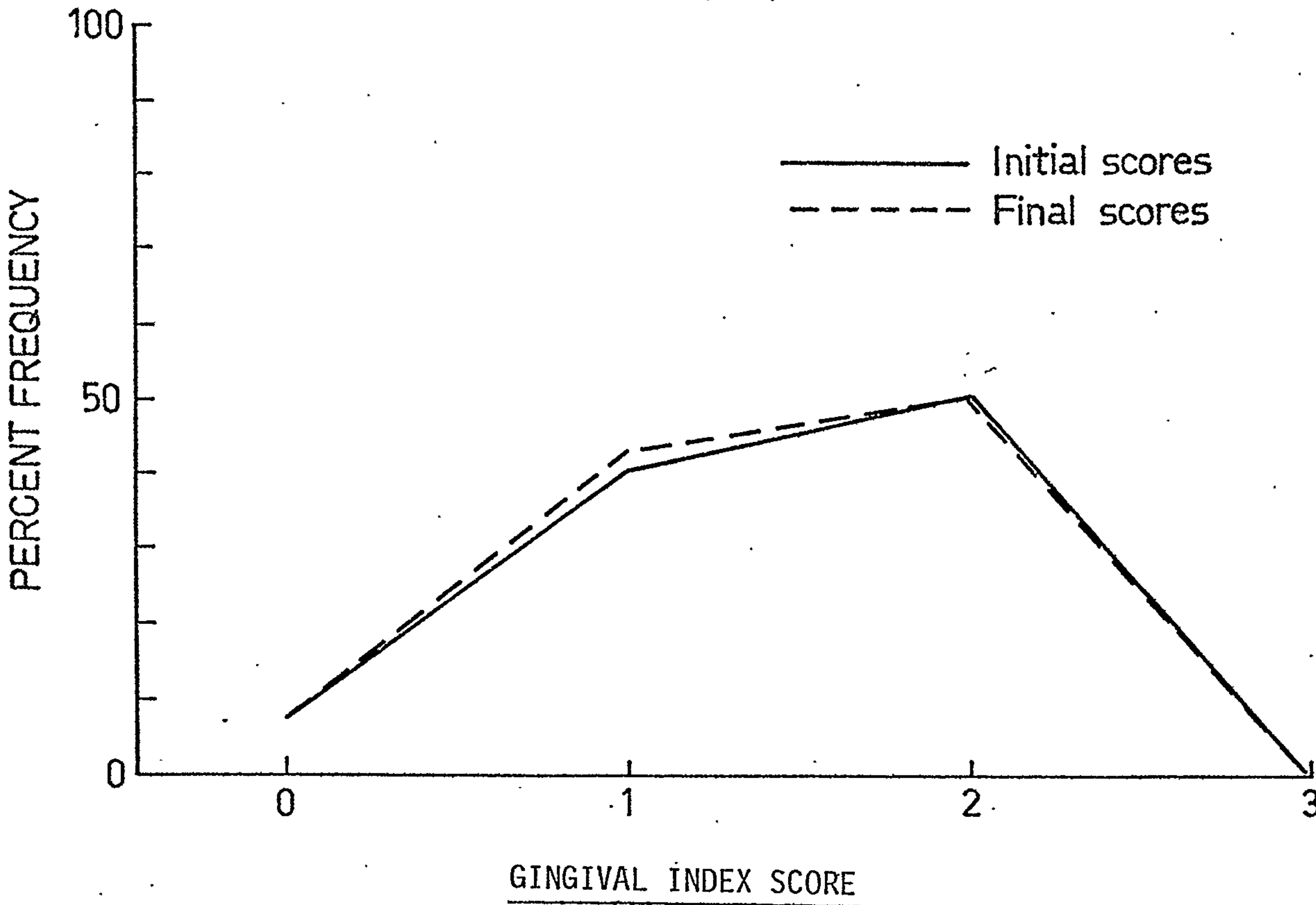


FIG. 17.

PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
GROUP I (EB)

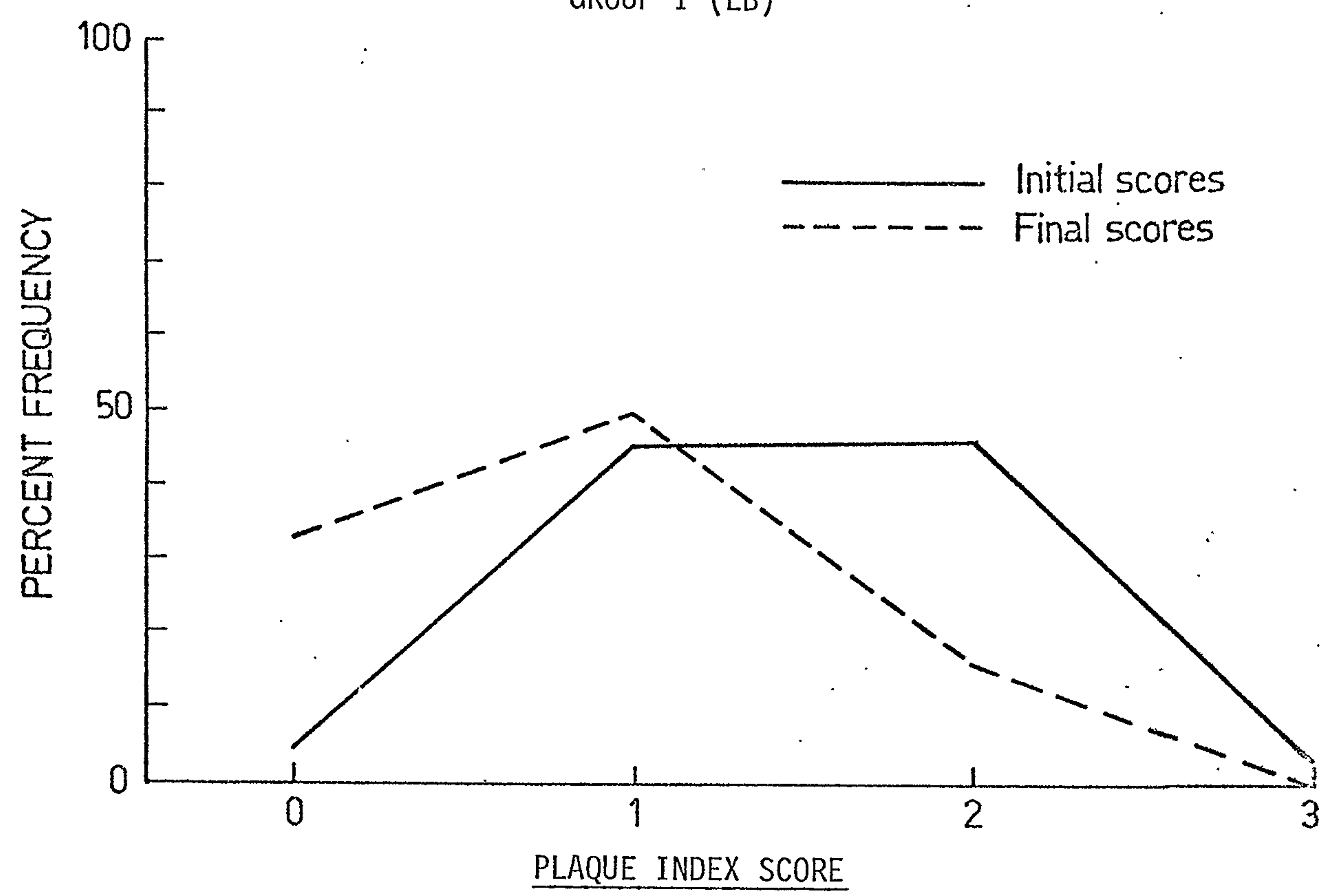


FIG. 18.

PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
GROUP II (ENB)

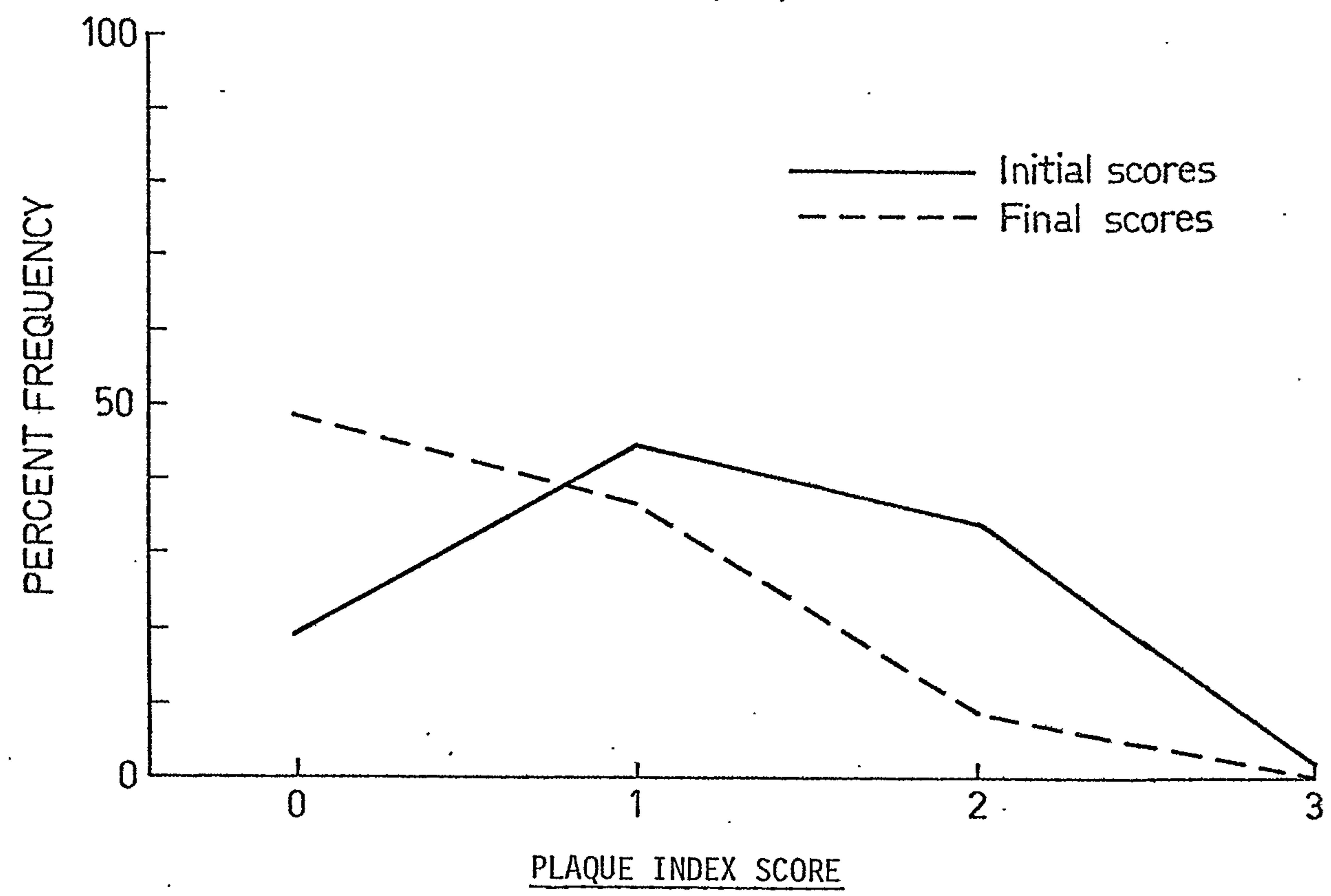


FIG. 19.

PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
GROUP III (CB)

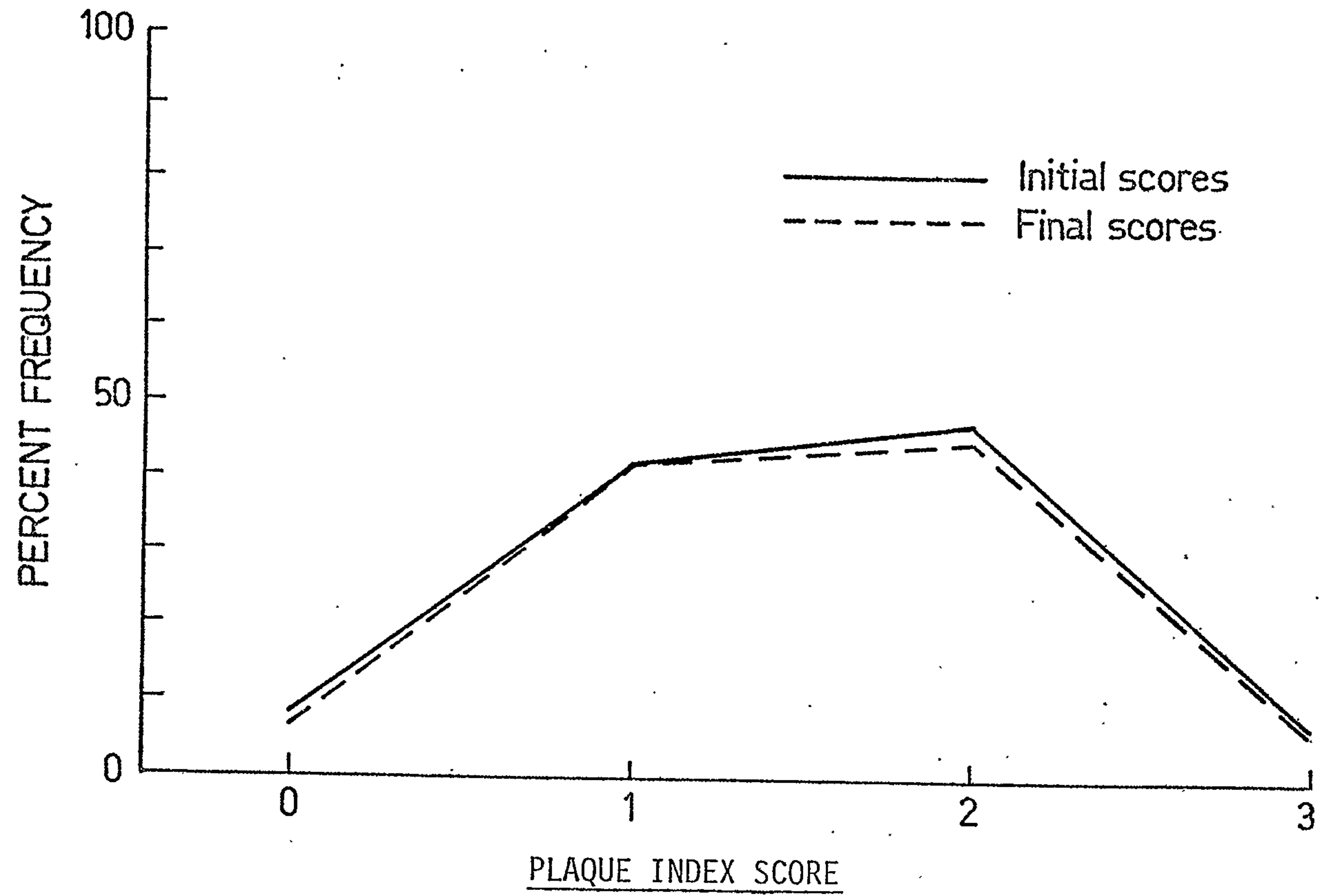


FIG. 20.

PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
GROUP IV (CNB)

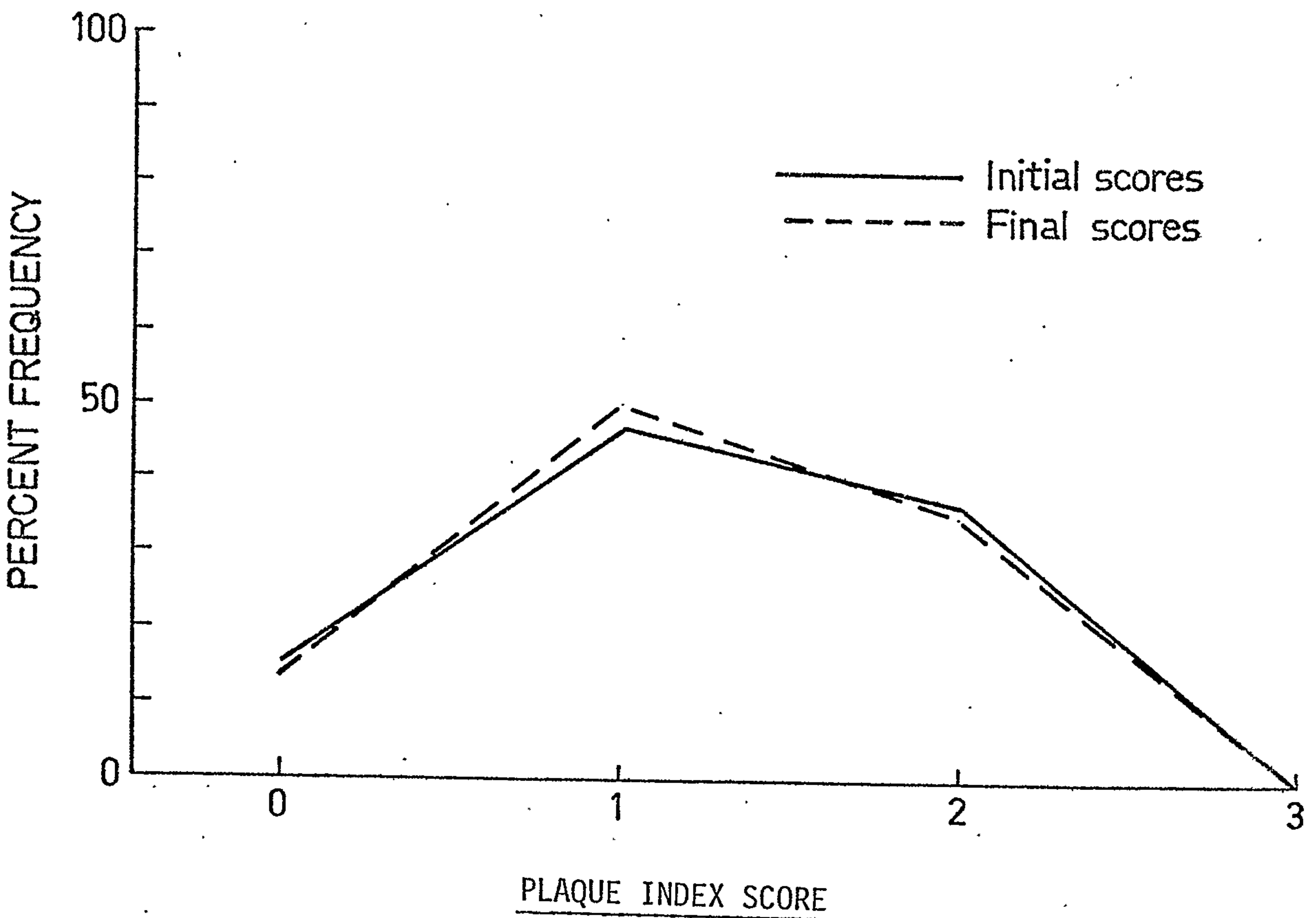


FIG. 21.

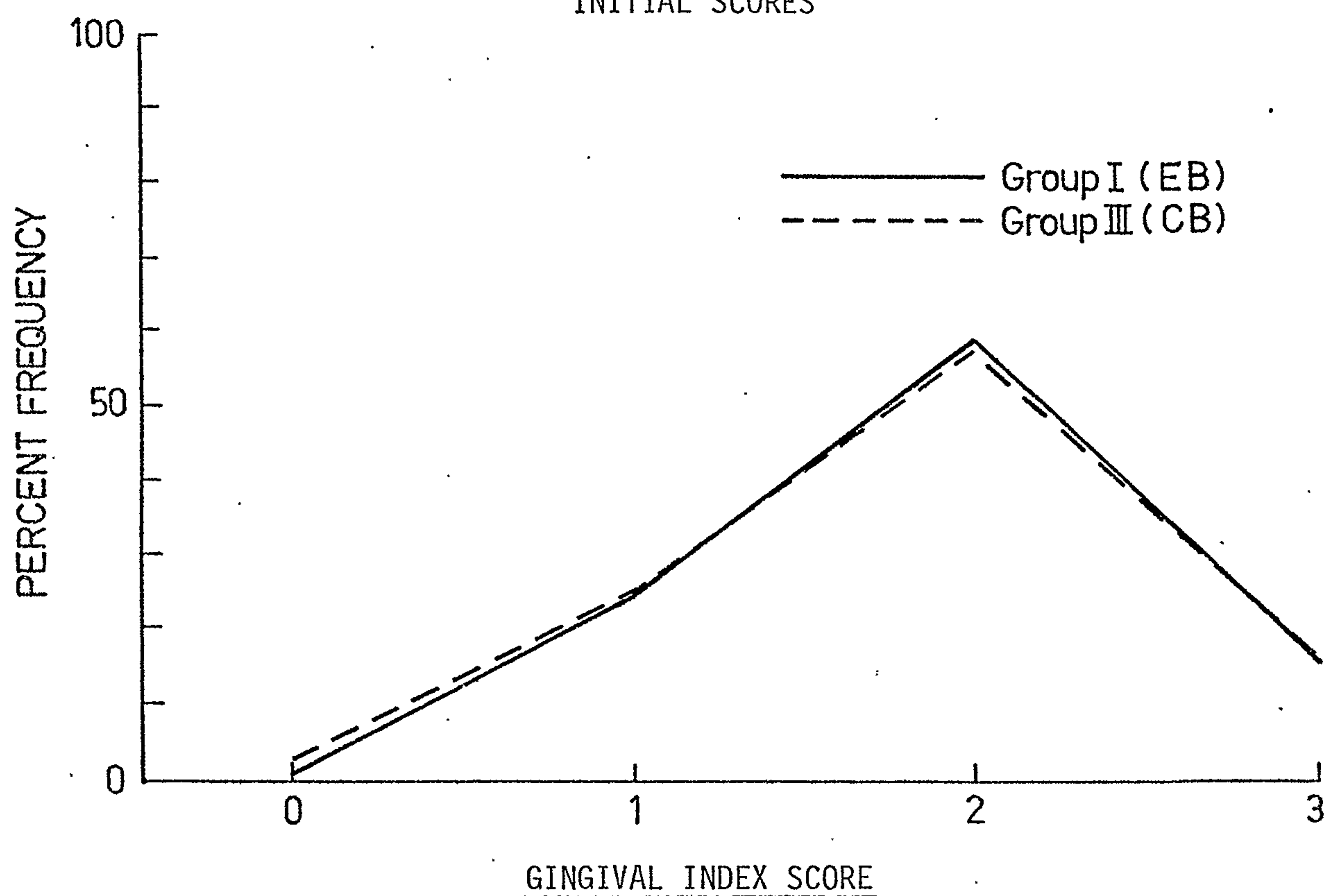
PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3
INITIAL SCORES

FIG. 22.

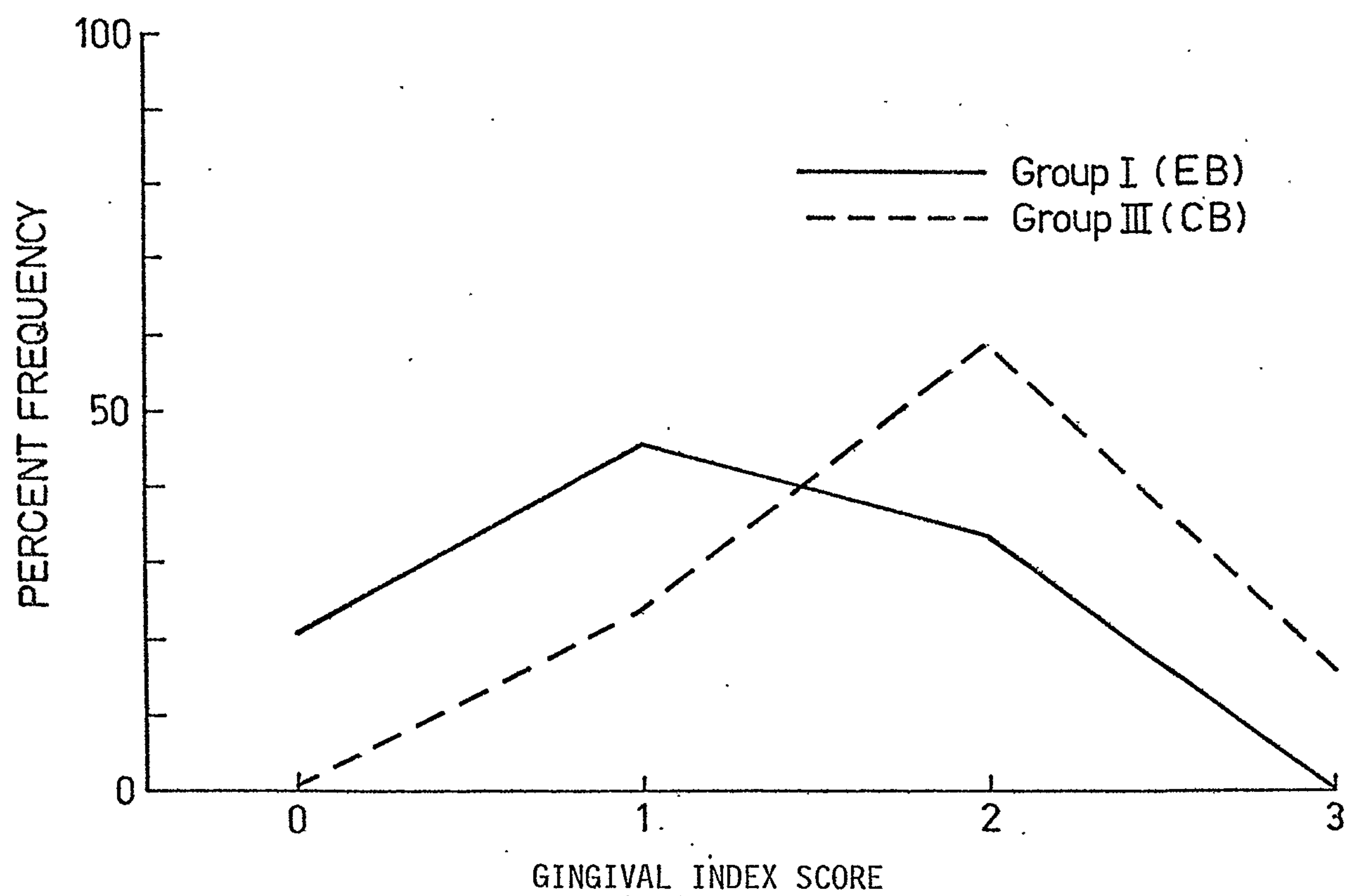
PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
FINAL SCORES

FIG. 23.

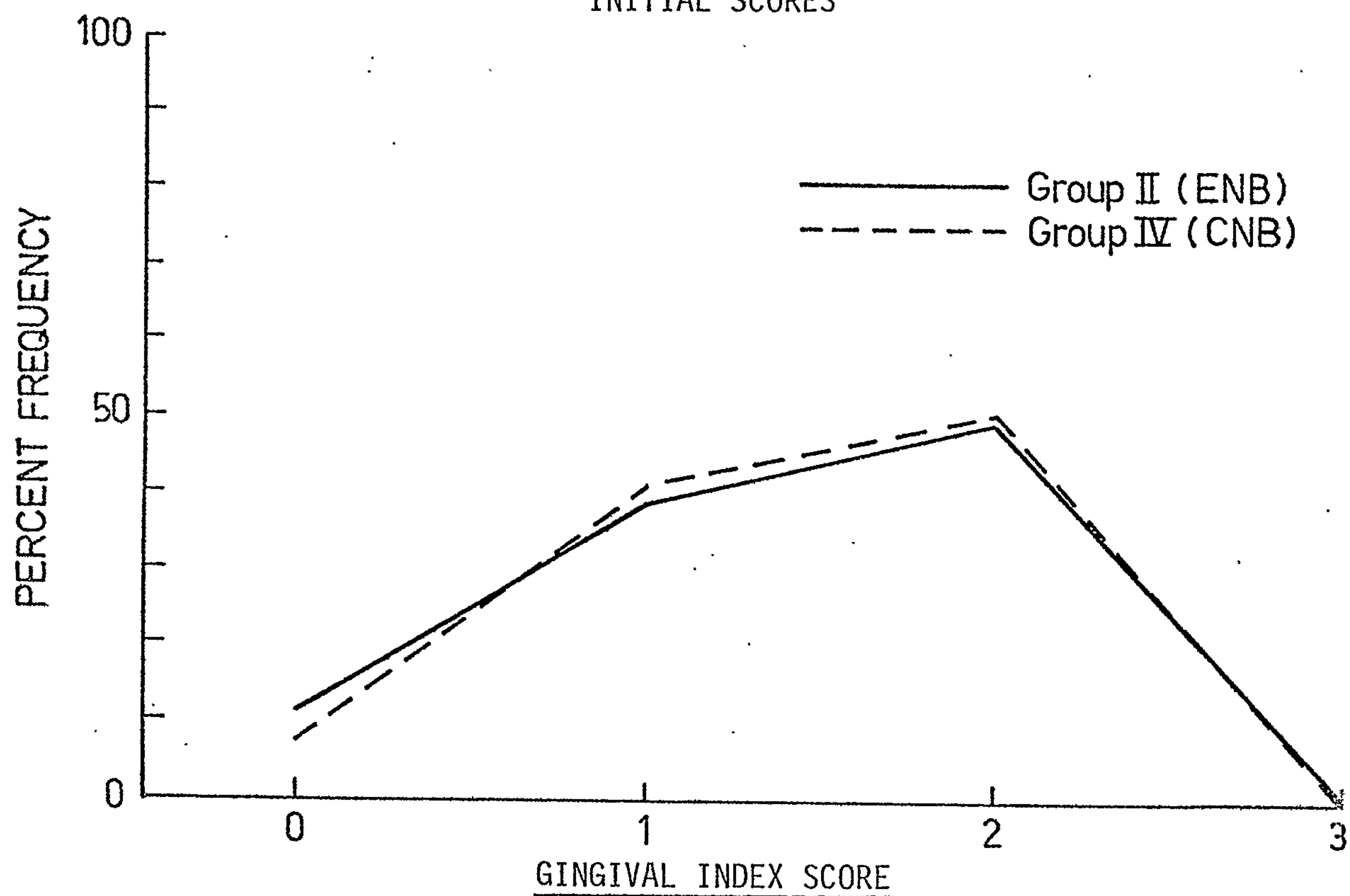
PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
INITIAL SCORES

FIG. 24.

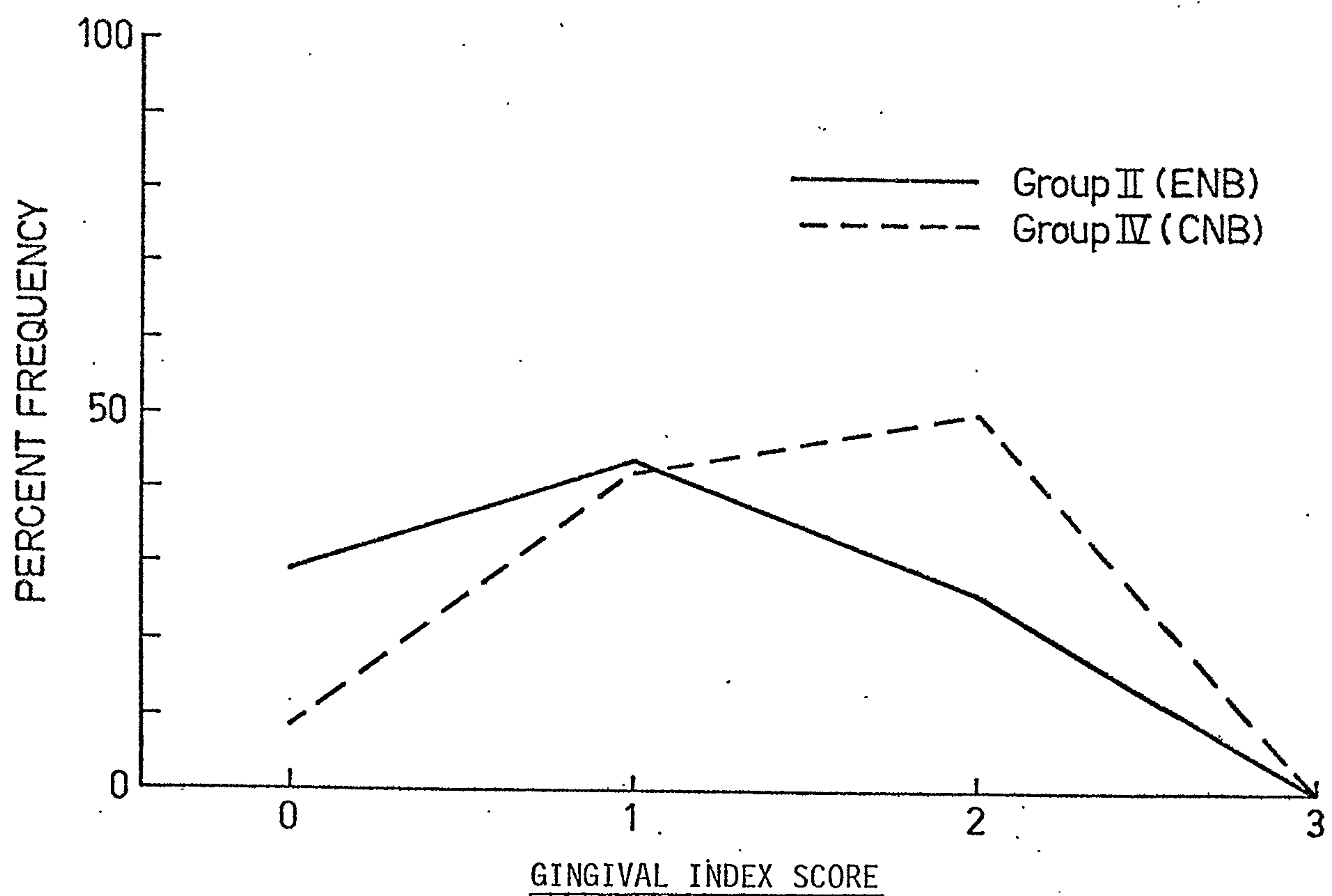
PERCENTAGE FREQUENCY GINGIVAL INDEX SCORES 0, 1, 2, 3.
FINAL SCORES

FIG. 25.

PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
INITIAL SCORES

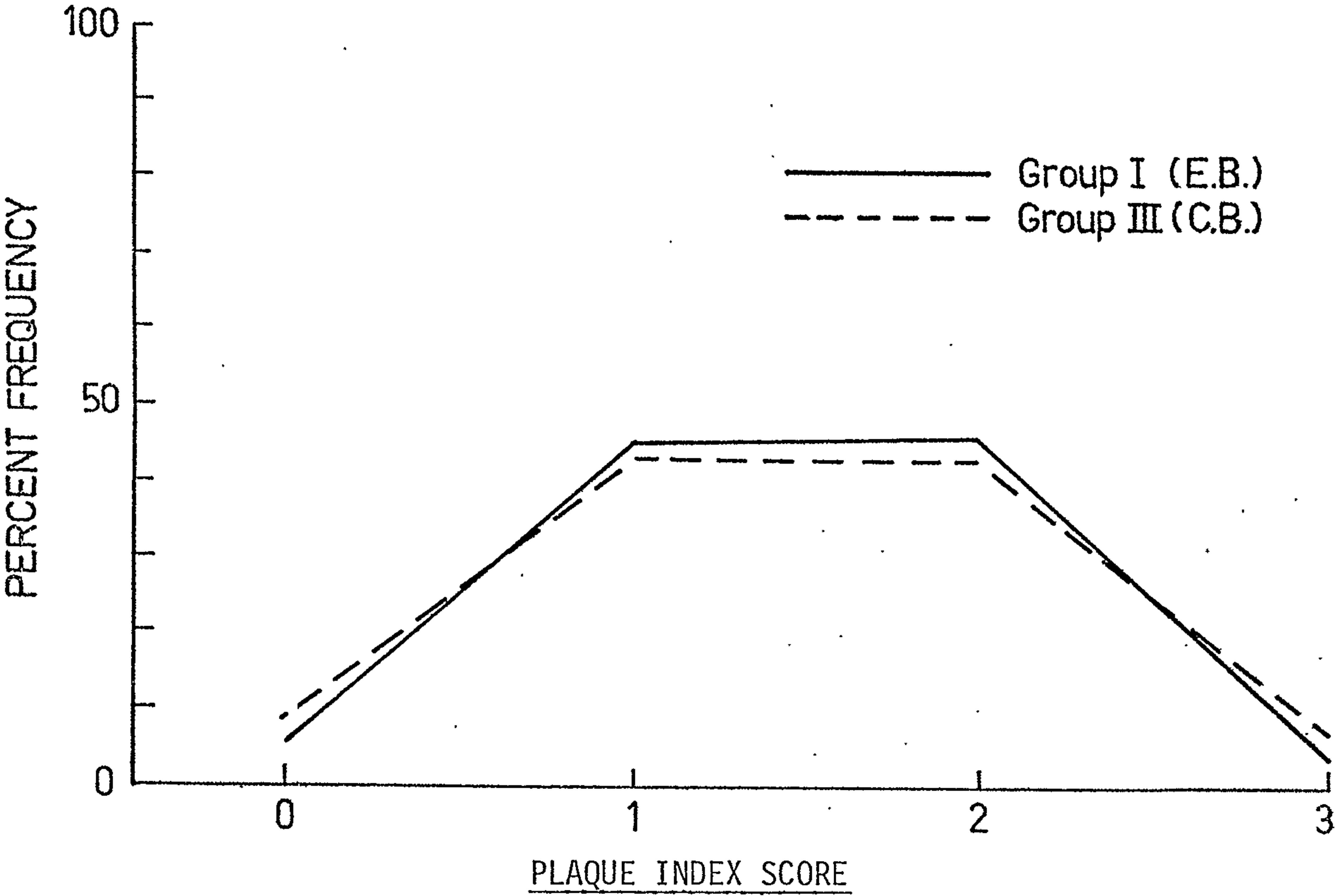


FIG. 26.

PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
FINAL SCORES

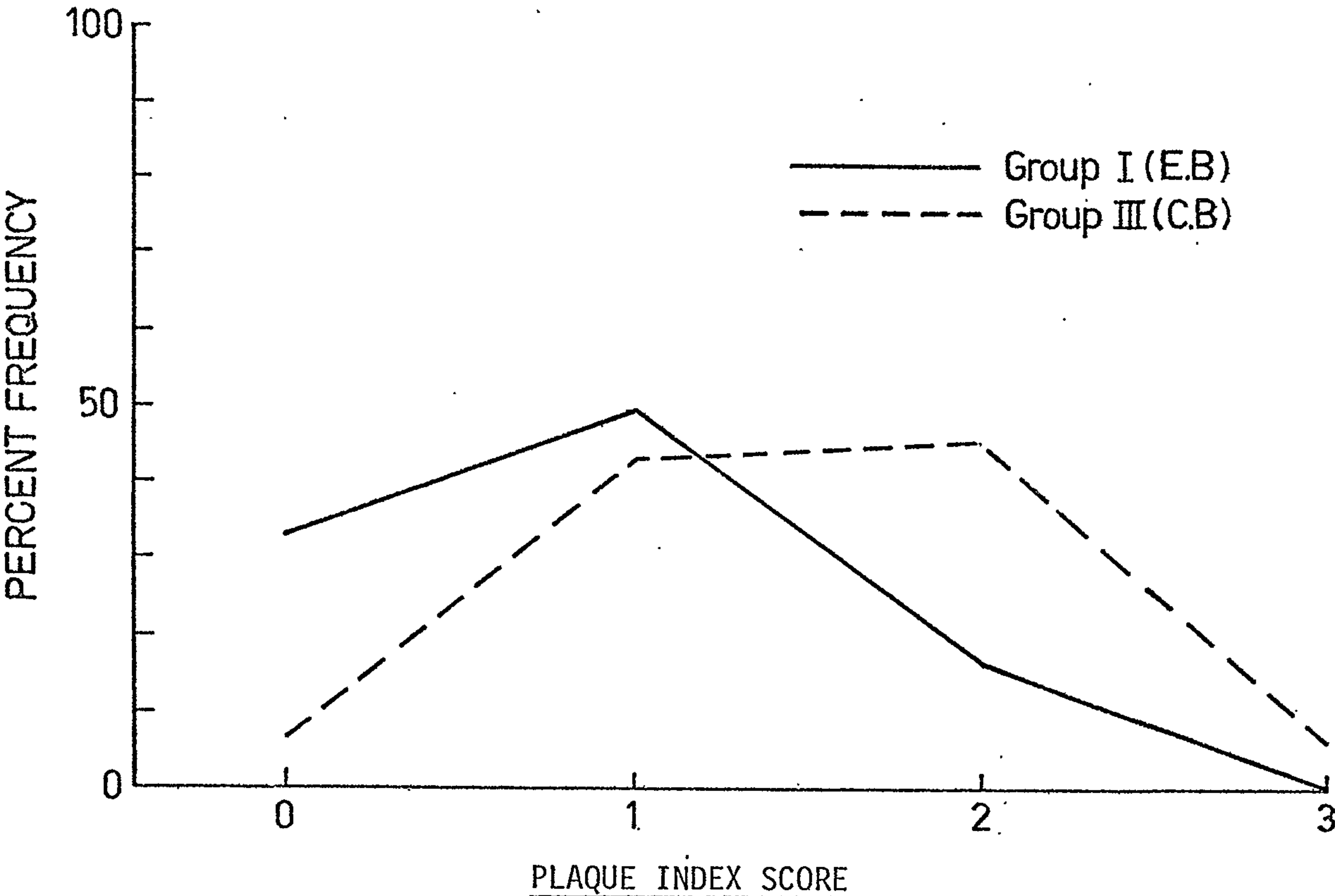


FIG. 27.
PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
INITIAL SCORES

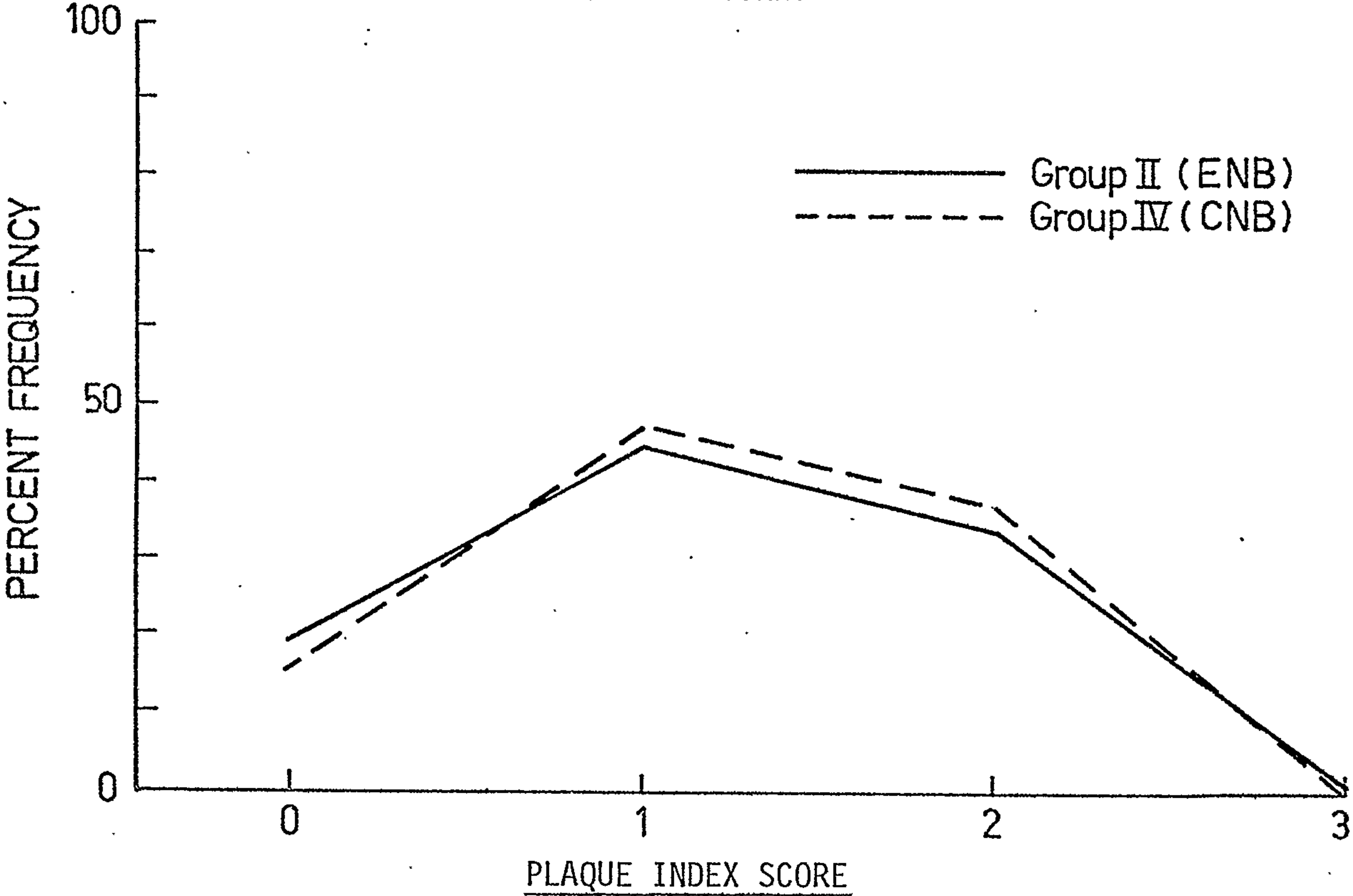
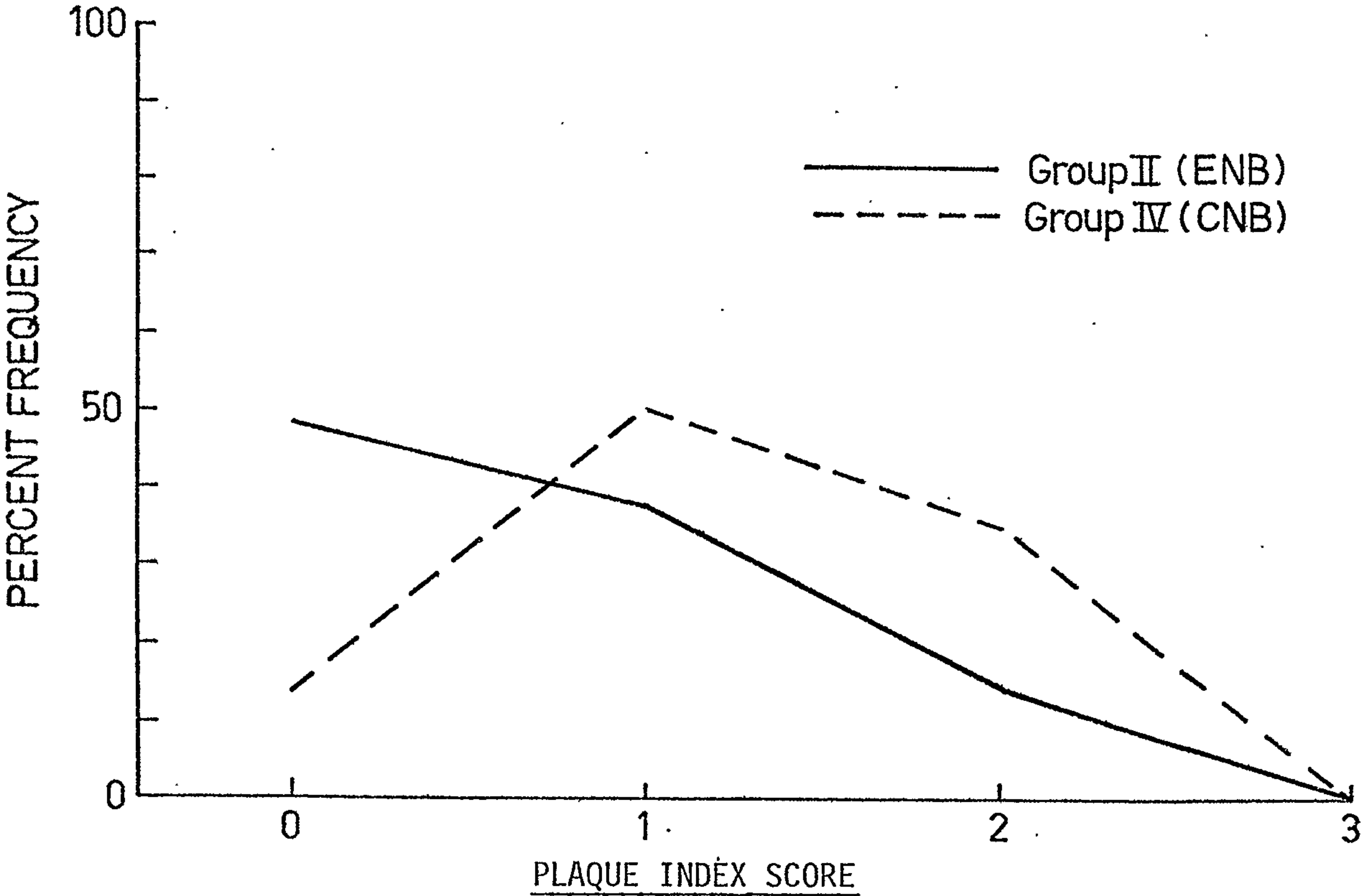


FIG. 28.
PERCENTAGE FREQUENCY PLAQUE INDEX SCORES 0, 1, 2, 3.
FINAL SCORES



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