CHAPTER 1

INTRODUCTION, MOTIVATION AND PURPOSE

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CHAPTER 1

INTRODUCTION, MOTIVATION AND PURPOSE

'Things should be made as simple as possible, but not any simpler' - Albert Einstein

1.1 INTRODUCTION

A number of inherited and environmental factors can play a role in the aetiology of malocclusion. The long development of the dentition makes it difficult to determine the role of individual factors in the development of malocclusion. According to Ricketts (1979), the development of malocclusion can be prevented or intercepted in many cases, if not in the majority.

Interceptive measures may have the advantage of simplicity and economy, but they must be applied at critical stages of development. Early detection of orthodontic abnormalities and interception is presently in the hands of the general dental practitioner. Although the practitioner may be strategically placed to detect abnormalities in the patients he or she sees, the chain of referral to an orthodontist often results in patients having orthodontic consultations too late for effective interception (Al Nimri & Richardson, 1997).

Malocclusion has interested epidemiologists for over twenty-four centuries since Hippocrates included the condition of 'crooked teeth' in his 6th book of Epidemics. However, it was not until 1899 that Angle attempted to classify types of malocclusion. Since then there have been many attempts to produce a malocclusion index which can be used to record both the prevalence of malocclusion, treatment need and priority, though there is still no malocclusion index which can assess all these items (Turner, 1990).

Specific defined malocclusions, where early recognition and simple interceptive treatment may minimise or eliminate the need for later complex appliance therapy (which would be necessary if treatment was delayed until a later stage of development) have been identified. This has led to the suggestion that it may be possible to screen the child population for developing malocclusions and to apply interceptive measures where appropriate.

If young patients could be treated in ways that will obviate the need for later comprehensive orthodontic treatment, it could mean that the total need for orthodontics at the permanent dentition stage could be reduced. This would allow health department clinics and private orthodontists an opportunity to handle a relatively larger percentage of patients with more extensive malocclusion.

1.2 MOTIVATION

Over the years a great number of orthodontic or so-called malocclusion indices have been developed. Some of these indices attempt to determine treatment need while others were developed to assess the quality of treatment. None of these indices were, however, specifically designed to determine the need for preventive- and interceptive orthodontic treatment.

With the current policy of the South African government to concentrate on Primary Health Care and the fact that there is an increasing demand for basic dental services in the country, more emphasis should be placed on the importance of preventive- and interceptive orthodontics as part of a Primary Health Care approach.

The importance of a normal and healthy primary dentition is well documented in the literature. A variety of epigenetic or environmental factors can influence the development of the permanent dentition during the long transition period from the primary dentition.

If a more normal dentofacial environment could be established by means of early preventive and/or interceptive orthodontic treatment, some of the malocclusions often seen in adolescence may be prevented.

Preventive and interceptive orthodontic measures can either eliminate the need for further orthodontic treatment or it can simplify precise tooth positioning during comprehensive orthodontic treatment. The aim of early intervention is to guide the development of the dentition and dentofacial growth.

Another important consideration is the fact that the cost of later comprehensive treatment can be reduced or, in some cases, even be eliminated.

Interceptive orthodontic treatment does not require specialised training and can be carried out by dentists, while certain preventive measures can even be carried out by dental therapists and oral hygienists.

1.3 PURPOSE

The purpose of this study was to develop an orthodontic index that would determine the need for preventive- and interceptive orthodontics in six- and nine-year-old children, and to test the reliability and validity of the application of this index.

CHAPTER 2

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CHAPTER 2

REVIEW OF THE LITERATURE

2.1 LITERATURE ON PREVENTIVE AND INTERCEPTIVE ORTHODONTICS

2.1.1 Introduction

Preventive and interceptive orthodontics mean different things to different people. Prevention in orthodontics should be accepted as a basic requirement for implementing successful public health dentistry. In order to prevent, we must anticipate and consequently avoid the occurrence of malocclusions. Should malocclusions occur, preventive measures must still be utilised to avoid the condition from becoming more critical or even irreversible (Simoes, 1981).

Ngan & Fields (1995) are of the opinion that preventive dentistry and essentially preventive orthodontics should begin during pregnancy. This is largely an educational phase, but one that can pay substantial dividends. Parents should be counselled on the advantages of postnatal, supplemental fluoride and oral hygiene to reduce dramatically the premature loss of primary teeth by caries.

Over the years, interceptive orthodontics has evolved clinically and adjectively. This is the subject which used to be called "preventive" orthodontics but the more recent term "interceptive" reveals a much better understanding of clinical possibilities and limitations (Richardson, 1982a). Implicit in the word preventive is the suggestion that the preventive measures can be applied before there is any sign or symptom of the condition which is to be prevented. Apart from a small number of irregularities which are produced entirely by environmental factors such as trauma, the foundations of most malocclusions are laid down at the moment of fertilisation. Consequently, there is little scope for prevention in orthodontic practice (Richardson, 1982a).

It is important that conditions that predispose one to develop a malocclusion of the permanent dentition, be detected early in the primary dentition (Ngan & Fields, 1995). This allows either intervention or monitoring on an effective basis. Good interceptive orthodontics is not easy and can be practised only against a sound knowledge of the development of occlusion and a clear understanding of the aetiology of malocclusion (Richardson, 1982a).

Varrela & Alanen (1995) highlights the fact that up to now, very little research activity in orthodontics has been directed toward true prevention of malocclusions like posterior crossbite, distal occlusion, or crowding.

2.1.2 Definitions

The definition given to prevention is "to ward off disease." In the case of orthodontics however, prevention must be regarded in a different light. Rather than prevent disease, its goal is to allow for the normal growth and development of the individual (Alexander, 1987). The prevention of malocclusion is possible only in a few special circumstances and possibly the only true form of preventive orthodontics continues to be caries control, obviating any appliance modalities. Although malocclusions on the whole are not "preventable", the measures we use to correct them should at least, not compromise our desired results (Alexander, 1987).

Popovich & Thompson (1975) define preventive orthodontics as any action taken to preserve the integrity of a normal occlusion, including all aspects of preventive dentistry.

Interception by definition means "to stop, deflect, or interrupt the progress or intended course" (Joondeph, 1993).

Interceptive orthodontic treatment is defined as procedures that eliminate or reduce the severity of a developing malocclusion. Interceptive orthodontics include deleterious habit consultation, consultations concerning operative work, removal of supernumerary

teeth, occlusion equilibration, slicing of mesial surfaces of deciduous cuspids, insertion of fixed and removable space maintainers and so forth.

According to Alexander (1987), interceptive orthodontics may be divided into the correction of dental and skeletal problems in children. Dental problems fall into four basic categories and should be treated by general dental practitioners:

i) Space maintenance

ii) Space regaining

iii) Mild crowding, and

iv) Dental crossbites.

Some apply the term interceptive orthodontics to any treatment in the mixed dentition which will prevent the establishment of a malocclusion, partially or totally. Richardson (1995) has placed emphasis on minimising unfavourable features of occlusal development where early detection and treatment may make the difference between achieving a satisfactory result by simple means as against prolonged mechanical treatment at a later stage.

Interception in this sense is probably nearer the traditional definition of preventive orthodontics than most (Al Nimri & Richardson, 1997). Seen from this perspective, the indications for interceptive treatment can be reduced to local factors, crowding, and displacements of the mandible in closing from the rest position. Local factors include impacted upper first molars, retained deciduous teeth related to malposed permanent teeth and delayed eruption of permanent teeth caused by supernumerary teeth where the benefits of early treatment are well-established (Munns, 1981).

Preventive orthodontics may be regarded as the procedures necessary to keep an occlusion within normal limits, while interceptive orthodontics would actually intercept a developing malocclusion in order to restore a normal occlusion.

2.1.3 Merits for early orthodontic treatment

In general the reasons to advocate early treatment are better stability, reduction in percentage of permanent tooth extraction, reduction in overall treatment time, and better functional or aesthetic end results (Ngan & Fields, 1995).

The objective of interceptive orthodontic supervision is to create a more normal dentofacial environment as early as possible to prevent the adaptations and limitations that are often associated with a significant malocclusion in late adolescence (Joondeph, 1993).

The single most important principle underlying all of the concepts regarding preventive and interceptive orthodontics is that it is essential to have a normal primary and mixed dentition as well as a normal transition between the primary, mixed and permanent dentitions in order to ultimately have a normal adult occlusion (Freeman, 1977). The time interval between the development of the primary dentition and the permanent dentition is a long period of approximately eleven and a half years. During this period there is much time for untoward changes to take place in the positions and functions of the unerupted and erupted permanent teeth. It has been one of the major goals of modern orthodontics to understand this transition process well enough to prevent or intercept developing malocclusion caused by aberrations in the developmental process (Ackerman & Proffit, 1980).

In the literature there is a fair deal of controversy about the merits and success of preventive and interceptive orthodontics. This stems from exaggerated claims at both poles. One group claims that almost all malocclusions can be prevented or intercepted (Terwilliger, 1950), while another group counters that almost no malocclusions are preventable (Fletcher, 1958). The truth probably lies somewhere between these polar views.

In essence preventive and interceptive orthodontics is the guidance and supervision of growth and development of the dentition. The

sequence of eruption, timing of eruption and the normal dimensional changes in the development of the dentition are all important considerations.

There are two reasons why early treatment may obviate compromise of quality i.e. it may remove aetiologic factors and restore normal growth and it may reduce the severity of the skeletal pattern, making possible easier and more precise tooth positioning in the adolescent (Moyers, 1988).

2.1.4 Early loss of primary teeth

Early loss of deciduous incisors in spaced arches may have remarkably little effect on crowding but removal of a deciduous molar usually produces a rapid and more or less extensive collapse of the buccal segment so that there is insufficient space for the succedaneous teeth. Most important of all is loss of the second deciduous molar because the first permanent molar comes forward very rapidly (Richardson, 1982b). Spaces in the upper jaw close more rapidly than in the lower and spaces close more quickly following loss of a second as against a first deciduous molar. The best treatment of premature extraction is true prevention so that the need for extraction does not arise, but if space maintenance is required the space maintainer must be inserted immediately after the tooth is extracted (Richardson, 1982b).

Space maintenance is appropriate only when space is available, adequate and all of the succedaneous teeth are present. It is foolish to consider maintaining space at an early age when the permanent successors are congenitally missing or if crowding is of such severity to require the extraction of permanent teeth (Alexander, 1987).

When deciding whether patients would benefit from space maintenance, the following must be taken into account (Richardson, 1982b):

i) Where the arches are generous in size or where there is congenital absence of teeth, there is no need to maintain space because space closure will be desirable.

ii) In cases where there is some crowding of the anterior teeth amounting to appreciably less than the breadth of a premolar in each quadrant, there is no need to maintain space because extraction of premolars or molars will be part of the treatment.

iii) Between these first two categories, there is the condition where there will be just enough space to accommodate the teeth in acceptable alignment. This is the classical indication for using a space maintainer.

iv) The last type of case is where extraction of a permanent tooth from the quadrant will give barely enough space to accommodate the other teeth in good alignment.

Unless particular care is taken to maintain arch symmetry and form, unilateral loss of primary cuspids should be avoided. If space maintainers with spurs distal to the lateral incisors are not placed, midline deviation can occur that may increase the complexity of the orthodontic treatment (Russell, 1996).

Guidelines for appropriate use of space maintenance in the mixed dentition were formulated from data in the Burlington Growth Study and were listed by Russell (1996) as follows:

i) Loss of maxillary primary incisors
   - No space maintenance is required if the primary cuspids are fully erupted.

ii) Loss of maxillary or mandibular primary canines
   - Space maintenance – bilateral.

iii) Loss of maxillary or mandibular primary first molars
   - If the permanent laterals and the first permanent molars are fully erupted, no space maintenance is required;
   - If in doubt – maintain space.

iv) Loss of maxillary or mandibular primary second molars

- Assess the eruption of the permanent second bicuspids and second molars;
- If the eruption of the second molars is prior to the eruption of the bicuspid, place a space maintainer;
- If the eruption of the second bicuspid is ahead of the second molar and sufficient to prevent mesial shift of the molar, space maintenance is generally not required;
- If in doubt – maintain space.

Space regaining is necessary if arch length has been lost prior to consultation with the dentist. Effective regaining in the amounts of 3mm is usually all that is possible. The recovery of space in the mandible is usually more difficult than in the maxilla due to anchorage requirements (Alexander, 1987).

2.1.5 Extraction of first permanent molars

According to Richardson (1982b) first permanent molar extractions seem to give the best results in the following circumstances:

i) The child should be aged 8 to 9 years and have some evidence of crowding.
ii) The fundamental arch relationship should be normal (Angle Class I).
iii) The overbite should be normal or reduced.
iv) All the permanent teeth should be present.
v) The first permanent molars should be carious.
vi) The unerupted lower second premolar should not be distally inclined or greatly spaced from the first premolar.

Late extraction of a lower first permanent molar after second molar eruption leads to much mesial tipping and rolling of the second molar. If extraction is done before eruption and root formation of the second permanent molar, however, intraosseous mesial movement of the second molar takes place resulting in a much more satisfactory occlusal and approximal relationship after eruption.

2.1.6 Ectopic eruption of first permanent molars

An extreme mesial eruption path in the first permanent molars may cause them to become impacted on the distal surface of the second primary molar. Particular attention should be paid to second primary molars that have been restored with stainless steel crowns and have increased interproximal convexities.

In such cases, the use of a separating elastic or a spring placed between the teeth will usually move the permanent molar far enough distally to create an unimpeded path of eruption. If separation is not successful, a removable appliance with finger springs may be required. Removal of the primary tooth, and the use of appropriate space maintenance, may also be necessary to allow the permanent molar to erupt (Russell, 1996).

2.1.7 Anterior crossbite

If the patient is first seen when the permanent incisors are still erupting, the overbite is still shallow and there is only one maxillary incisor in lingual occlusion, the tooth may be moved over the bite by making the patient bite on a tongue spatula. The spatula should be inserted as nearly vertical as possible and the child should bite on it for at least two periods of fifteen minutes each day (Richardson, 1982a). If, however, the overbite is more established or more than one incisor is involved, it is better to use an upper removable appliance.

2.1.8 Posterior crossbite

The prevalence of posterior crossbite in the deciduous dentition seems to vary between 8% and 16%, with predominance for unilateral crossbite. Forced guidance in the transverse direction has been registered in most of these cases (Thilander et al, 1984). In a study by Lindner & Modeer (1989), ninety-seven percent of the seventy-six patients with unilateral posterior crossbites showed a forced bite with a functional shift on closure. One likely cause of the relatively high percentage of unilateral crossbite in the early dentition is the influence of finger- and dummy sucking.

Lateral functional shifts usually result from a narrow maxillary arch that is in an end-to-end buccal relationship with the mandibular arch at initial contact. To create a functional stable cusp-to-fossa relationship, the patient's mandible shifts laterally and it appears as if the patient has a unilateral crossbite in centric occlusion (Russell, 1996). Proper diagnosis of this type of malocclusion (at initial contact) includes the identification of a bilateral maxillary lingual crossbite with a lateral functional shift. Treatment consists of bilateral expansion of the maxillary arch.

The prevalence of posterior crossbite in the mixed and permanent dentition has been found to be of the same magnitude as in the deciduous dentition, the great majority of cases being unilateral and very often associated with forced guidance.

This uniform prevalence of crossbite in different stages of the dentition indicates that crossbite in the deciduous dentition is seldom self-correcting (Kutin & Hawes, 1969).

Lateral shift of the mandible to the crossbite side results in lower midline discrepancy, asymmetric condylar positioning, contralateral dental-arch asymmetry (crossbite side toward Class II sagittal relationship, non-crossbite side toward Class I relationship) and facial asymmetry with chin deviation to the crossbite side in occlusion (Ngan & Fields, 1995).

Early treatment with grinding, alone or in combination with an appliance for expansion, is therefore advisable in order to reduce the prevalence of crossbite and probably, in some cases, eliminate the need for treatment in later stages of bite development (Kutin & Hawes, 1969). On the other hand, Leighton (1966) claimed that crossbite should not be routinely treated in the deciduous dentition because of the high rate of spontaneous correction.

In a study by Kutin & Hawes (1969), primary dentition crossbites observed longitudinally without intervention showed only 8,65 percent (3 out of 35) self-correction in the mixed dentition. On the other hand,

correction in the primary dentition increases the chance of no crossbite in the permanent dentition, and recurrence of crossbite is low (Ngan & Fields, 1995). According to the study by Schroeder & Schroeder (1984), thirty-two children aged three to six years with high and narrow palatal vaults and functional posterior crossbites of the primary dentition who were treated by transverse expansion showed no relapse when the permanent first molars were in occlusion. An eight-year longitudinal study by Thilander et al (1984) has shown that out of the 33 children treated early for posterior crossbite, only 9 showed correction of the crossbite after grinding of the sharp cusps of deciduous canines. Subsequent interceptive treatment with expansion appliances resulted in correction of the crossbite in a further 17 children. Of the 28 children where no corrective treatment had been performed during the observation period only 6 showed spontaneous correction. The authors recommend that treatment of posterior crossbite should be started by judicious grinding in the deciduous dentition. If there is no effect, an orthodontic appliance should be applied in the early mixed dentition.

Bilateral posterior crossbite generally results from significant skeletal maxillary constriction and can be corrected by opening the midpalatal suture (Ngan & Fields, 1995). Occasionally, a patient may present with a true unilateral maxillary posterior constriction. These cases can be diagnosed by the presence of a unilateral posterior crossbite in centric relation and centric occlusion and the absence of a lateral shift to compensate (Ngan & Fields, 1995).

2.1.9 Anterior open bite

Open bite can occur as a result of a skeletal or dental problem. Those with skeletal problems and disproportionately long lower faces are difficult to treat because the vertical dimension continues to change into adolescence. On the other hand, open bite is often seen in children who have good skeletal proportions and sucking habits (Ngan & Fields, 1995).

2.1.10 Anterior deep bite

Deep bite malocclusion is usually associated with the skeletal proportions that predispose to this condition: a relatively short face with a square gonial angle and flat mandibular plane (Ngan & Fields, 1995). This is classically the Class II Division 2 patient for whom intervention for the Class II malocclusion would be delayed. Generally, treatment of deep bites is not indicated in the primary dentition, unless clear functional problems or irritation of the palatal tissue from lower incisor impingement is noted (Ngan & Fields, 1995).

2.1.11 Supernumerary teeth

Rotation or delayed eruption of a central incisor or a large persistent midline diastema are the early signs of an unerupted supernumerary tooth in close relation to the upper incisors. Interceptive treatment, in the form of extraction of the supernumerary tooth and exposure of the incisor is usually rewarded by spontaneous eruption if adequate space is available. The eruption rate is typically rapid for the first few months but, on average, 2 years of patient observation are needed before the incisor reaches the general occlusal level (Richardson, 1982c).

2.1.12 Ankylosis of deciduous teeth

A submerged deciduous molar is often, but by no means invariably, associated with absence of the corresponding premolar. These deciduous teeth are not really submerged in the sense that they have sunk down into the bone. The true explanation is that they have remained in a fairly constant vertical position while the adjacent teeth and alveolar processes have grown up round them.

Ankylosis, which often occurs round these submerged teeth, is best detected by percussing the tooth with the mirror handle when the note will be heard reverberating through the bone. Sometimes these teeth may become completely submerged and more or less resorbed (Richardson, 1982c).

2.1.13 Deleterious habits

2.1.13.1 Thumb- and/or fingersucking

The sucking of fingers or a thumb often produces a malocclusion. On the other hand there are many children who suck a digit without any apparent effect on the dentition. The determining factors are the frequency, intensity and duration of the habit (Richardson, 1982c).

Melsen et al (1979) found that both digital sucking and pacifier sucking increased the tendency toward abnormal swallowing. Sucking habits were strongly correlated with distocclusion and open bite and with crossbite and maxillary overjet. A Class II Division 1 malocclusion can be aggravated by thumbsucking, which usually produces a forward movement of the maxillary anterior teeth, accompanied by a lingual movement of the mandibular anterior teeth and an anterior open bite. Thumbsucking may also disturb the posterior occlusion, as the tongue spreads over the occlusal surfaces while sucking, thus causing a posterior or lateral infraclusion (O'Meyer, 1976). O'Meyer is of the opinion that one should act as soon as possible during the early deciduous dentition. In some cases eliminating the habit may bring about a spontaneous correction.

Usually sucking habits are spontaneously stopped or reduced to a minimal level because of peer pressure, before the appearance of permanent teeth. In general, up to age five or so, sucking habits are unlikely to cause any long-term problems in children with good skeletal patterns (Ngan & Fields, 1995). Some data indicate that ultimately the distortions promoted by non-nutritive sucking habits in terms of open bite and overjet are resolved by the teenage years without any treatment (Thilander et al, 1984).

There are many approaches to the correction of thumbsucking and prevention of bad habits during childhood and these include the use of a splint to prevent the child from bending his elbow, pinning the baby's

sleeve to its side, the use of gloves and finger stalls or of bitter aloes. When the child is old enough, a small removable plate or cemented bands with a crib will serve as a reminder to the thumb (O'Meyer, 1976).

2.1.13.2 Abnormal breathing patterns

Some vertical dentofacial problems and open bites have been blamed on breathing patterns (Linder-Aronson et al, 1986). The relationship between these variables is difficult to quantify and it is certainly more difficult to assign causality on the basis of the data (Ngan & Fields, 1995). Before any surgical intervention involving the tonsils and adenoids is undertaken, a thorough and objective evaluation of respiratory mode should be undertaken (Fields & Sinclair, 1990).

Chronic nasal obstructions, such as allergic rhinitis, may be associated with an adaptive low, anterior tongue posture and mouth breathing (Joondeph, 1993). Mouth breathing is considered to have a genetic basis, and there is evidence that it has an unfavourable influence on the maxilla and teeth. Neuromuscular alterations can be observed if nose breathing is defective or non-existent. The mandible and the tongue are dropped to allow the air to pass into the oral cavity, and strong pressure of the buccal muscles as well as tongue pressure on the mandibular teeth can lead to a buccal crossbite (O'Meyer, 1976). The compensatory tongue and breathing patterns may contribute to altered dentofacial growth patterns characterised by vertical facial development, maxillary constriction with high palatal vault, and open bite dental pattern (Joondeph, 1993). Early identification of this potential problem with restoration of a patent nasopharynx in combination with appliance therapy to improve dentofacial relationships may reduce the progressive nature of these changes.

2.1.13.3 Abnormal swallowing

According to O'Meyer (1976), abnormal swallowing is due to anatomic and psychological factors and should not be regarded as a habit. When a child swallows normally, the mandible is elevated and the teeth are brought together. The tongue is held against the palate behind the maxillary anterior teeth and the lips are closed. When the child swallows abnormally the teeth are separated, the mandible is dropped and the tongue is thrust between the teeth during the last stages of swallowing. Abnormal swallowing can be an aetiological factor in malocclusion, because the tongue applies pressure to the anterior teeth and increases the overjet. Simultaneous contraction of the mentalis muscle may push the lower incisor lingually aggravating the overjet. The tongue thrust between the teeth may cause an anterior or lateral open bite (O'Meyer, 1976).

Teaching the correct swallowing pattern takes a considerable time and much effort on the part of the dentist, the speech therapist and patient. The best results are obtained with children who have developed abnormal swallowing associated with thumbsucking. Patients with an atypical skeletal pattern have a predisposition to abnormal swallowing and they are the most difficult to treat. Successful results depend on careful diagnosis (O'Meyer, 1976).

2.1.14 Abnormal frenum labii

The presence of a large and fleshy frenum is often associated with a diastema between the upper central incisors. On the other hand, it is possible to find a large frenum with no midline diastema and a midline diastema with only a small frenum. Even though a cause-and-effect relationship is not proven it is best to excise a frenum if a large diastema is to be closed (Richardson, 1982c).

2.1.15 Serial extraction

Indications for serial extraction:

i) Crowded incisors at age 8 or 9.

ii) Angle Class I arch relationship.

iii) Normal or reduced overbite.

iv) All permanent teeth should be present.

v) The first permanent molars should have a good prognosis.

vi) The first premolars should be more close to eruption than the canines.

Russell (1996) highlights the fact that a minimum of 10mm crowding in both arches should be present and that the overjet should be normal.

The following steps in a serial extraction are described by Richardson (1982b):

i) When the child is aged about 8 and the lateral incisors are erupting in crowded positions, the deciduous canines are removed to allow spontaneous alignment of the laterals.

ii) When the roots of the first deciduous molars are half resorbed, they are removed in order to precipitate early eruption of first premolars.

iii) As soon as the first premolars erupt, they are removed to make way for the erupting canines.

It is rather rare to find a patient who fulfils all of these criteria to the letter. In theory, the incisors, canines and second premolars should erupt in good alignment following the serial extraction procedure but in practice most patients need some appliance therapy which will be shorter and simpler than if crowding had been allowed to develop before orthodontic intervention (Richardson, 1982b).

2.1.16 Pseudo Class III

In a pseudo Class III malocclusion, anterior functional crossbites occur when the maxillary incisors are retroclined and/or the mandibular incisors are proclined such that the incisors meet in an end-to-end relationship. Although this malocclusion is a Class I dentoalveolar malocclusion with an anterior functional shift, it is referred to as a pseudo Class III dental relationship (Russell, 1996). In these cases, because there is no skeletal component to the malocclusion, the treatment can be performed by a general dentist. Patients who have a skeletal malocclusion that is contributing to the anterior crossbite should be referred to an orthodontist (Russell, 1996).

It is important to clinically differentiate between a pseudo Class III dentoalveolar malocclusion and a skeletal malocclusion. With pseudo Class III malocclusion, the initial contact is between the incisors. Since this relationship is unstable, the mandible shifts forward (anterior functional shift) to obtain a stable and functional dental relationship. Trauma to the mandibular incisors is common, and the periodontal condition of these teeth is often compromised (Russell, 1996).

While a pseudo Class III malocclusion can be corrected using removable or fixed appliances with relatively stable results, true skeletal Class III malocclusion requires long-term monitoring throughout puberty (Ngan & Wei, 1988). Most clinicians prefer to delay treatment of this type of malocclusion until the permanent dentition is intact, because mandibular growth is difficult to control.

2.1.17 Distoclusion (Class II)

According to a longitudinal study by Bishara et al (1988), all cases with a distal step occlusion in the primary dentition resulted in a Class II permanent first molar malocclusion, which will not self-correct with growth.

In the treatment of a skeletal Class II malocclusion, either fixed or removable appliances may be used to restrict or redirect anterior

maxillary development allowing normal mandibular growth to correct this antero-posterior disharmony (Joondeph, 1993).

Early treatment of skeletal Class II problems in the primary dentition is not recommended because of the lack of scientific evidence on the long-term effects of such treatment (Ngan & Fields, 1995).

2.2 LITERATURE ON ORTHODONTIC INDICES

2.2.1 Definition of an index

Baume and Maréchaux (1974) define an index as a number which serves as an indicator in order to express a certain condition or a proportional ratio, which can be deduced from a series of observations.

2.2.2 Purpose of a malocclusion index

The use of indices should ensure uniform interpretation and application of criteria. Although numerous indices have been developed none as yet has been accepted universally. The use of precise criteria is essential, requiring a quantitative objective method of measuring malocclusion and efficacy of treatment (Richmond et al, 1992a).

At least three main reasons can be stated why the accurate measurement of occlusal variation and occlusal disorder is considered important (Jago, 1974):

i) It could determine the priority of need by patients who have occlusal disorders and whose resources are limited when they seek treatment under publicly funded programs. Categorising malocclusions into various groups, according to the urgency and need for treatment could well help to assign priority to individuals with the greatest need when orthodontic resources are limited and when the availability of treatment is unevenly spread (Brook & Shaw, 1989).

ii) It could be used to estimate the need for treatment in a population and gain a view for training adequate manpower to meet both actual and potential demand for such treatment.

iii) It could be used to record data objectively for many different kinds of populations and complement the existing objective data on other facets of the craniofacial complex. Epidemiologic studies of malocclusion offer a valid research tool for ascertaining the operation of distinct environmental and genetic factors in the aetiology of malocclusion (Baume & Maréchaux, 1974). Malocclusion indices may be used to throw light on the relationship between different types of malocclusion so as to widen knowledge of their aetiology and hence increase the possibility of preventing them (Björk et al, 1964).

Accurate assessment of occlusal variation is bound to be important for determining priority of need under publicly funded programs, to estimate the needs for treatment in a population and to increase the profession's scientific knowledge (Jago, 1974).

Because of the nature of malocclusion, however, there are many limitations that affect the objectives of any assessment method that may be adopted. Malocclusion is not a single entity, but rather a collection of situations, each in itself constituting a problem (van Kirk & Pennell, 1959).

2.2.3 Requirements for an index

The requirements for all indices have been summarised in the 1966 World Health Organisation report on international methodology for epidemiological studies of oral diseases.

i) A dental index should be reliable, that is have a high level of intra- and inter-examiner reproducibility.

ii) It should be valid, measuring what it is intended to measure.

iii) It should be valid during time, that is the index should consider the normal development of the occlusion.

The index must concentrate and be sensitive to the basic orthodontic defect rather than the symptom, so for an index to be valid over a period of time, the index score of the occlusal disorder should either remain constant or increase over that period (Turner, 1990).

There are four basic principles by which an epidemiologic method is applied to the study of any disease or anomaly, in particular dentofacial anomalies (Moyers & Summers, 1970):

i) Define the problem. This is the most important, yet is often the most difficult principle to achieve.

ii) Find the factors of causation of the anomaly as well as its distributions by studying the affected population, that is define the "chain of events" which produce the resultant anomaly.

iii) Formulate the principles for a program of control, based upon the demonstrated causes and directed towards the prevention of the defect or disability. This is usually achieved by altering one or more of the links in the chain of events.

iv) Evaluate the results of the control measures.

Shaw et al (1991) gave the following ideal properties of an index:

i) A basic requirement of any index or system of measurement is that it should be valid and reproducible. Validity is the ability of an index to measure that which it purports to measure, whereas reproducibility is the ability to reproduce the original ratings or scores when the subject is re-examined by the same or a different examiner.

ii) The index should be easy to learn, ideally allowing rapid recording of relevant features by both trained dental and non-dental personnel.

When using an index to determine the need for orthodontic treatment for public health purposes, it should be possible to distinguish patients with a prior need for treatment from those with no actual need for treatment (Järvinen & Väätäjä, 1987). According to Freer (1972) an

index of severity, used to determine an individual's eligibility for treatment, should assign an absolute and not a relative score to the individual. An index based on ranked or ordered scores would apply to the individuals of that sample only, since the ranked scores would change as soon as the composition of the sample changes when the results from longitudinal research becomes available. The index should also be flexible enough to allow changes in the cut-off point at which individuals are accepted for treatment. The number of individuals treated may then be varied with the availability of personnel and funds (Freer, 1972).

Regardless of which index is being used, it should be both precise and unbiased (Grewe & Hagan, 1972). To be truly useful, an index must be applicable universally without modification and should be quick to use (Cons et al, 1989).

2.2.4 Orthodontic indices

Whilst indices have been used with some success for recording other dental disorders (caries, periodontal disease, and temporomandibular dysfunction), malocclusion is unique in presenting as a group of often unrelated traits to which, in social psychological terms, there may be considerable variability of adjustment. Despite these considerable problems, several indices of malocclusion have been developed and have been used for diagnostic classification, epidemiological data collection, the recording of treatment need (treatment priority) and assessment of the success of treatment (Shaw et al, 1991).

2.2.4.1 The Handicapping Labio-lingual Deviation Index (HLD)

The HLD was developed by Draker (1960). It was an attempt to obtain a method which would complement and perhaps substitute for clinical judgement which, although useful to a degree, is vulnerable because it is entirely subjective. According to Draker the presence or absence of a demonstrable handicap is the only factor of public health interest. In our preoccupation with the definition and classification of

"malocclusion" however, we have lost sight of this. Because the word "malocclusion" implies a diagnosis, arrived at by consideration of aetiology and differential diagnosis, he prefers the term handicap. This indicates a problem which should be far easier to detect, because it is disfiguring.

Initially a score sheet was designed to evaluate 9 factors influencing the social acceptability of an individual. A score of 13 and over constituted a physical handicap. The weighting factors were however developed by trial and error. The HLD data sheet, showing 7 components only, was later developed. This included:

i) Cleft palate
ii) Traumatic deviations
iii) Overjet
iv) Overbite
v) Mandibular protrusion
vi) Open bite
vii) Labio-lingual spread

The index can be applied to both the patient and to models, without need for special equipment. The HLD Index yields a cut-off point for program acceptance, which can be adjusted to correspond to budget changes, without abandoning the objectivity of measurements.

2.2.4.2 Treatment Priority Index (TPI)

The Treatment Priority Index (TPI) was developed by Grainger in 1967 to determine whether orthodontic treatment reduced the level of public health significance. Thereafter the TPI's usefulness was recognised for epidemiological surveys of malocclusion and as a screening tool in public health programs (Ghafari et al, 1989).

The TPI was based on the evaluation of models or clinical examinations of 375 12-year-old children (Grainger, 1967). The items measured were restricted to those describing an occlusal anomaly,

excluding factors related to cause (such as habits), or measurements related to malocclusion per se (such as intercanine width). Set patterns or combinations of the selected items defined syndromes. A total of 7 syndromes evolved defining the incisor relationship horizontally and vertically, the occlusion of the buccal segments, and tooth displacement (rotation and crowding). On the basis of multiple regression analysis, the syndromes were weighted according to the first permanent molar relationship, mesio-, neutro-, and distocclusion. A constant, also corresponding to the molar occlusion, was added to the TPI score. The final TPI value could range from 0 to >10.

In a study by Ghafari et al (1989) to evaluate the predictability of the TPI as an indicator of the severity of a malocclusion, the authors found that, although the TPI is an acceptable indicator of malocclusion, malocclusion predictability may not depend on TPI values recorded in the transitional dentition. The results of this study also proved its use to gauge the efficacy of orthodontic treatment, albeit not necessarily early (preventive/interceptive) treatment. It was found that the TPI is a valid epidemiologic indicator of malocclusion but does not predict the severity of individual malocclusions in the permanent dentition. Thus determination of the need of orthodontic treatment must remain an individual assessment.

Turner (1990) found that although the level of correlation between clinical judgement and the rankings obtained from a modified TPI are comparable to other studies, it still does not identify certain facets of malocclusion which orthodontists include as indicators of treatment required.

2.2.4.3 The Handicapping Malocclusion Assessment Record

The assessment record provides guidelines and weights for the assessment of the severity of malocclusion without the use of millimetre measurements, to provide a means for establishing priority

for treatment in the individual child. With the help of the HMA forms, a random sample is obtained of the frequency and range of severity of the malocclusion that occurs in the child population in the community (Salzmann, 1968). A cut-off point is set at an assessment score that will permit treatment of patients by the professional personnel available in the community and in keeping with the funds budgeted for orthodontics.

The purpose of the Handicapping Malocclusion Assessment Record form is to provide a means for establishing priority for treatment of handicapping malocclusion in the individual child according to severity as shown by the magnitude of the score obtained in assessing the malocclusion from dental casts or directly in the oral cavity (Salzmann, 1968).

Handicapping malocclusion and handicapping dentofacial deformity are conditions that constitute a hazard to the maintenance of oral health and interfere with the well being of the child by adversely affecting dentofacial aesthetics, mandibular function, or speech. The Handicapping Malocclusion Assessment Record form was not designed to ascertain the presence of occlusal deviations ordinarily included in epidemiologic surveys of malocclusion or for clinical orthodontic examinations. Aetiology, diagnosis, planning and complexity of treatment, and prognosis are not factors in this assessment (Salzmann, 1968).

2.2.4.4 The Summers Occlusal Index (OI)

The Occlusal Index was employed in the most recent epidemiological studies in the Republic of South Africa. According to Summers (1971), malocclusions consist of 2 main groups i.e. orthodontic defects and symptoms due to development defects. It is important that an index be more sensitive to orthodontic defects, than to symptoms. These defects could be skeletal, dental or neuromuscular.

Nine characteristics are scored in the Occlusal Index:

i) Dental age
ii) Molar relation
iii) Overbite
iv) Overjet
v) Posterior crossbite
vi) Posterior open bite
vii) Tooth displacement (actual and potential)
viii) Midline relations
ix) Missing permanent teeth

Unusual conditions, such as congenitally missing teeth, supernumerary teeth, cleft palate, etc. can be noted in the "remarks" section of the form.

All individuals are classified into one of 5 categories:

i) Good occlusion – no evidence of an occlusal disorder.
ii) No treatment – slight deviations in occlusion, but no treatment indicated at this time.
iii) Minor treatment – minor deviations in the occlusion which could be remedied by simple treatment.
iv) Definite treatment – major deviations in the occlusion which could be remedied by major treatment.
v) Worst occlusion – major deviations in the occlusion which could be remedied by major treatment; these occlusions are highly disfiguring to the patient and would probably rank first in treatment priority.

The Occlusal Index contains two divisions and seven syndromes:

Divisions I and II	Normal or distal occlusion (categorised with similar
Division III	connotations as the Angle classification system).
Syndrome A	Overjet and open bite.
Syndrome B	Distal molar relation, overjet, overbite, posterior crossbite, midline diastema and midline deviation.

Syndrome C	Congenitally missing incisors.
Syndrome D	Potential tooth displacement and tooth displacement.
Syndrome E	Posterior open bite.
Syndrome F	Mesial molar relation, overjet, overbite, posterior crossbite, midline diastema and midline deviation.
Syndrome G	Mixed dentition analysis and tooth displacement.

Having selected the appropriate coding sheet based upon developmental age, each item of assessment is placed in the appropriate division which is determined on the basis of the molar relationship and then all scores are placed in the syndromes of that division. Correct assessment of the molar relationship is therefore critical in the use of the Occlusal Index (Buchanan et al, 1993).

The specially designed data sheets, for recording the weighted scores for each feature or measurement are complicated and they require the user to make mental adjustments to the positions of certain teeth before making the measurements (Elderton & Clark, 1983).

2.2.4.5 The Children's Oral Health Status Index (COHSI)

Koch et al (1985) developed the Children's Oral Health Status Index as a composite health status index of paediatric populations. The index unites four easily measured variables – decay, missing teeth, abnormal position, and occlusion – which characterise both decay and its consequences and orthodontic considerations. It summarises these diverse elements into a single number that provides an indication of overall health status. The index can be tabulated quickly by direct examination of each child (Koch et al, 1985).

2.2.4.6 Dental Aesthetic Index (DAI)

The Dental Aesthetic Index is an orthodontic index based on socially defined aesthetic norms and was developed by Cons et al (1986). It is a regression equation that links mathematically the public's perceptions

of dental aesthetics with the objective physical measurements of the occlusal traits associated with malocclusion. The DAI is particularly sensitive to occlusal conditions that have the potential for causing psychological or social dysfunction (Jenny & Cons, 1996).

The components of the DAI is as follow:

i) Number of missing visible teeth (incisors, canines and premolars in the maxillary and mandibular arches).
ii) Assessment of crowding in the incisal segments.
iii) Assessment of spacing in the incisal segments.
iv) Measurement of any midline diastema in mm.
v) Largest anterior irregularity on the maxilla in mm.
vi) Largest anterior irregularity on the mandible in mm.
vii) Measurement of anterior maxillary overjet in mm.
viii) Measurement of anterior mandibular overjet in mm.
ix) Measurement of vertical anterior open bite in mm.
x) Assessment of antero-posterior molar relation (largest deviation from normal either left or right).
xi) Constant of 13

Each individual score is then multiplied by a weighting factor and the scores are then summed to get the total for a specific patient.
The further a DAI score falls from the norm of most acceptable dental appearance the more likely the occlusal condition, if left untreated, may be either socially or physically handicapping or both (Jenny & Cons, 1996).

2.2.4.7 The Peer Assessment Rating Index (PAR)

The concept of the PAR index is to assign a score to various occlusal traits, which make up a malocclusion. The individual scores are summed to obtain an overall total, representing the degree a case deviates from normal alignment and occlusion (Richmond et al, 1992a).

In order to develop this index of treatment standards, a series of meetings with a group of ten experienced orthodontists was convened. Study casts of various treated and untreated occlusions were examined and discussed until agreement was reached about the individual features which would be assessed in order to obtain an estimate of alignment and occlusion. A scoring system was developed and a ruler designed to allow analysis of a set of study casts in approximately two minutes.

Individual scores for the components of alignment and occlusion are finally summed to calculate an overall score. Thus, a score of zero would indicate perfect alignment and occlusion and higher scores (rarely beyond 50) indicate increasing levels of irregularity.

The index is applied to both the start and end of treatment study casts, and the change in the total score reflects the success of treatment in achieving overall alignment and occlusion (Shaw et al, 1991).

There are eleven components of the PAR Index (Richmond et al, 1992a):

i) Upper right segment
ii) Upper anterior segment
iii) Upper left segment
iv) Lower right segment
v) Lower anterior segment
vi) Lower left segment
vii) Right buccal occlusion
viii) Overjet
ix) Overbite
x) Centreline
xi) Left buccal occlusion

Weighting factors are added to the overjet (6), overbite (2) and centreline (4) measurements.

A ruler has been designed to make measurement easier. The information briefly summarises the recording features of the index and facilitates quick assessments, and allows contact points to be viewed through the ruler.

In order to determine the examiner reliability a stratified subsample of 38 cases was selected from a random sample of 2000 treated and untreated cases. The dental casts were measured on two occasions eight weeks apart. Differences in measurements were estimated by calculating the Intraclass Correlation Coefficient of Reliability (Richmond et al, 1992a).

In order to test the validity of the PAR Index seventy-four dentists were invited to participate, representing the various groups carrying out orthodontic treatment in England and Wales. Each member of the panel of examiners was asked to assess a representative sample of dental casts with respect to deviation from normal occlusion on a nine-point scale. For each dental cast a mean score was obtained from the panel of seventy-four examiners representing consensus opinion (Richmond et al, 1992a).

Richmond et al (1992b), using the weighted PAR Index, revealed that at least a thirty percent reduction in PAR score is required for a case to be considered as "improved" and a change of twenty-two PAR points to bring about "great improvement".

The PAR Index was developed to measure the standard of treatment and several studies have been published where this index was used to compare pre- and post-treatment study casts (Fox, 1993; Kerr et al, 1993; Birkeland et al, 1997).

2.2.4.8 The Index of Orthodontic Treatment Need (IOTN)

This index ranks malocclusion in terms of the significance of various occlusal traits for the individual's dental health and aesthetic impairment, with the intention of identifying those individuals who would be most likely to benefit from orthodontic treatment (Shaw et al, 1991). The index incorporates a dental health and aesthetic component.

In the dental health component (DHC) each occlusal trait thought to contribute to the longevity and satisfactory functioning of the dentition is defined and placed into five grades, with clear cut-off points between the grades (Shaw et al, 1991). The DHC categorises cases from grade 1 (no need for treatment) to grade 5 (great need). It may be applied both clinically and to study casts. When applied to study casts, it should be noted that there are minor differences in the definition of some traits (Shaw et al, 1991).

Summing scores for a series of individual traits is not performed. A specially designed ruler is used to note and measure the various features of malocclusion.

The aesthetic component (AC) consists of a 10-point scale, illustrated by a series of numbered photographs, which were rated for attractiveness by lay individuals and selected as being equidistantly spaced through the range of scores (Evans & Shaw, 1987). A rating is allocated for overall dental attractiveness rather than specific morphological similarity to the photographs. The value arrived at, gives an indication of the patient's treatment need on the grounds of aesthetic impairment, and by inference reflects the sociopsychological need for orthodontic treatment.

The time taken to record both the dental and aesthetic components by an experienced examiner is approximately 1 minute. However if several minor traits require examination to identify the most severe, grade allocation may take up to 3 minutes (Shaw et al, 1991). As all traits are simple to record, it may be possible for less highly trained

personnel to apply the index, following suitable training and calibration (Brook & Shaw, 1989).

In a study by Buchanan et al (1994) the Index of Orthodontic Treatment need (IOTN) was applied to a group of patients and later to study models and photographs taken at that same visit. Examiner reliability and agreement between the information obtained clinically and from diagnostic models was high. There was however, poor agreement for the Aesthetic component scored from photographs, when compared with scores recorded clinically or from models.

The IOTN has been successfully used in studies to assess the need for orthodontic treatment (Richmond et al, 1994) and is gaining popularity worldwide.

2.2.4.9 The World Health Organisation method for the epidemiological assessment of malocclusion

Dental Aesthetics Index (DAI) criteria are used. It is recommended that this index be used for age groups in which there are no longer primary teeth, usually from 12 years.

The criteria used are:

- Missing incisors, canine and premolar teeth
- Crowding in the incisal segments
- Spacing in the incisal segments
- Diastema
- Largest anterior maxillary irregularity
- Largest anterior mandibular irregularity
- Anterior maxillary overjet
- Anterior mandibular overjet
- Vertical anterior open bite
- Antero-posterior molar relation
- Need for immediate care and referral

The CPI probe is used when measuring anterior irregularities, overjet and open bite (World Health Organisation, 1997).

2.2.4.10 Occlusion Feature Index (OFI)

The Occlusion Feature Index was developed at the National Institute of Dental Research, California in 1957 and is based on four primary features of occlusion which are of importance in an orthodontic examination (Poulton & Aaronson, 1961):

i) Lower anterior arch crowding in the 3-3 area.

ii) Cuspal interdigitation, observed in occlusion.

iii) Vertical overbite, measured by that portion of the lower incisors covered by upper central incisors in occlusion.

iv) Horizontal overjet, measured in occlusion with a small ruler.

A value is assigned to each of these features according to certain objective criteria and a total score may be obtained by adding them together. The possible range is from 0-9.

2.2.4.11 Social Acceptability Scale of Occlusal Conditions (SASOC)

The Social Acceptability Scale of Occlusal Conditions measures the relationship between occlusal morphology and social functioning as a factor in assessing treatment needs and predicts which occlusal morphologies might become a social handicap for an individual (Jenny et al, 1980).

2.2.4.12 Need for Orthodontic Treatment Index (NOTI)

In Norway a new orthodontic treatment need index was introduced in 1990 for allocation of refunds of treatment costs by the National Health Insurance system. It is called the Need for Orthodontic Treatment Index (NOTI).

The index defines four groups or grades, denoting very great need, great need, obvious need, and little/no need. Traits presumed to be associated with concern for dental appearance and to cause psychosocial problems were incorporated in the index, although based solely on professional estimates (Espeland et al, 1992).

2.2.4.13 Malocclusion Severity Index (MSI)

The Malocclusion Severity Index (MSI) was developed by applying a series of weighting scores to the various occlusal anomalies recorded in a survey including 9-, 12-, and 15-year-old Glasgow schoolchildren. In order to establish this realistically, reference was made to the relationships reported in the literature between malocclusion and dental health.

Reference was also made to scores employed in the Treatment Priority Index (TPI) (Grainger, 1967), the Occlusal Index (OI) (Summers, 1971) and the Handicapping Malocclusion Assessment Record (HMAR) (Salzmann, 1968) to gain an insight into the appropriate range of scores employed (Hill, 1992).

Since crowding is the most prevalent occlusal anomaly, the MSI was developed by applying a series of weighting scores to this aspect of malocclusion. This approach enabled realistic scores to be ascribed to the remaining occlusal anomalies. The overall score for each individual was calculated as being representative of the severity of malocclusion and therefore the treatment priority (Hill, 1992).

The MSI was found to be as reproducible and valid as previously developed indices. The relative simplicity of the method and the minimal time required for each individual examination indicated that it could be considered suitable for use in epidemiologic surveys either as a tool for screening the orthodontic treatment needs on a priority basis or else for comparing the prevalence of malocclusion in different sample populations (Hill, 1992).

2.2.4.14 Ideal Tooth Relationship Index (ITRI)

The Ideal Tooth Relationship Index was developed to look at inclined planes, interproximal contacts, anterior occlusal contact and specific cusp and marginal ridge relationships. The use of the ITRI has many applications such as evaluating the results of orthodontic treatment, post-treatment stability, settling, relapse, and different orthodontic

treatment modalities. The index is based on actual to potential ideal relationships present (Haeger et al, 1992).

2.2.4.15 Standardised Continuum of Aesthetic Need (SCAN)

Based on the fact that different levels of dental attractiveness can be consistently discriminated by individuals and panels (Howells and Shaw, 1985), Evans and Shaw (1987) developed a simple 10-point rating scale illustrated by representative dental photographs across the range of values. Scores obtained in this way have various uses:

i) The prioritising of cosmetic treatment need.

ii) Patient counselling, and

iii) As an independent research variable in studies of stereotyping, patient compliance or treatment effectiveness.

2.2.5 Conclusion

The indices most commonly in use today are the Index of Orthodontic Treatment Need (IOTN), Peer Assessment Rating (PAR) Index and the Dental Aesthetic Index (DAI). The PAR Index was developed to assess treatment outcome and does not measure treatment need. The DAI is based on socially defined aesthetic norms and this index as well as the Social Acceptability Scale of Occlusal Conditions (SASOC), Need for Orthodontic Treatment Index (NOTI) and Handicapping Labio-lingual Deviation Index (HLD) evaluate factors influencing the social acceptability of an individual. The IOTN and Summers Occlusal Index (OI) can be applied to the mixed dentition but they do not specifically indicate the need for early orthodontic intervention. The World Health Organisation recommends that their method of assessing malocclusion be used for age groups in which there are no longer primary teeth (usually from 12 years), and Ghafari et al (1989) reported that the Treatment priority Index (TPI) does not accurately predict malocclusion in the transitional dentition.

It is important to have an index that examines and measures features relevant to preventive an interceptive orthodontics, especially in countries where the emphasis is on Primary Health Care. Such an index will give an indication of the need for early orthodontic intervention and will also identify those individuals with a greater need for treatment. Identifying the severity of the problem and determining treatment priority are important factors to consider when the funds available for preventive and interceptive orthodontics are limited.

It can therefore be concluded that none of the indices described in this review of the literature were specifically developed to determine, or give an indication of, the need for preventive and/or interceptive orthodontic needs, and that the need existed to establish an index for this purpose.

CHAPTER 3

MATERIALS AND METHODS

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CHAPTER 3

MATERIALS AND METHODS

3.1 AIM OF THE INDEX FOR PREVENTIVE AND INTERCEPTIVE ORTHODONTIC NEEDS (IPION)

The index attempts to rank malocclusion in a population of 6- and 9-year-old children in terms of the significance of various occlusal traits for preventive and/or interceptive treatment. It therefore intends to identify those children who would most likely benefit from early preventive and/or interceptive orthodontic treatment. The index does not necessarily give an indication of the prevalence of malocclusion, since a severe malocclusion may be graded in a low treatment need category, due to the impracticability and/or inadvisability of rendering either preventive or interceptive treatment at this time.

Because of the fact that different factors have an influence on the development of malocclusion in 6- and 9-year-olds, certain factors are excluded during the examination of 6-year-olds. It was therefore suggested that a clear distinction be made between the two sets of criteria, resulting in two indices. Although the two indices are based on the same principles, they are used on different age groups, and it was therefore decided to call them the IPION-6 and IPION-9 indices respectively.

3.2 COMPONENTS OF THE IPION

Scores are assigned to the various occlusal traits that make up the malocclusion. The individual scores are multiplied by weighting factors and then summed to obtain a total that represents the degree a case deviates from the "normal" alignment and occlusion for this age. The score of zero indicates good occlusion and higher scores indicate an increased need for preventive and/or interceptive orthodontic

treatment. The plastic IPION ruler (Figure 1) was designed to ensure that the information needed to use the index are always at hand when examining a patient. The ruler is also used to perform measurements on the patient or dental cast.

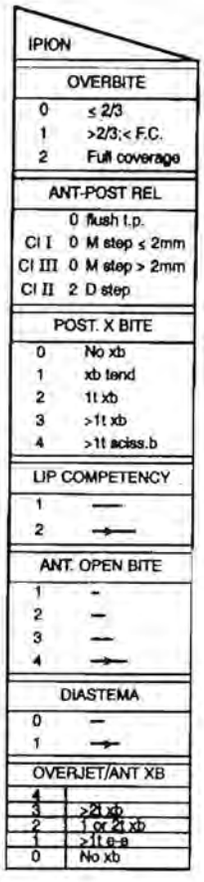

Figure 1 **The IPION ruler**

There are 5 components of the IPION:

i) Primary component
ii) Anterior component
iii) Posterior component
iv) Occlusion, and
v) Soft tissue

3.2.1 IPION-6

The IPION-6 assesses the need for preventive and interceptive orthodontic treatment in 6-year-olds and consists of the following components.

3.2.1.1 Primary component

- Interproximal caries:

Scores are recorded for both the upper and lower primary molars and cuspids as well as for the first permanent molars. Occlusal and interproximal carious lesions are recorded, since they could lead to early loss of teeth and/or influence the stability of available arch length. Scores are noted according to the number of teeth involved if the marginal ridge of the tooth is still intact (***a score of 1*** for each affected tooth). If the marginal ridge is not intact, ***a score of 2*** is recorded for that specific tooth. A score of 0 indicates that there are no carious lesions present.

- Premature loss of primary teeth:

Premature loss of primary teeth result in space loss in the dental arches. In the IPION-6 the number of missing first and second primary molars as well as the number of primary cuspids are scored. If the primary teeth were not prematurely lost (i.e. is still present) a score of 0 is recorded.

3.2.1.2 Anterior component

- Supernumerary teeth:

The highest prevalence of supernumerary teeth is in the maxillary midline region. The presence of an unerupted mesiodens can lead to the impaction of the permanent incisors and if erupted can take up unnecessary space and cause crowding. The number of supernumerary teeth present in the mouth mesial to the canines is recorded.

Due to ethical and cost implications, radiographs can not be taken during an epidemiological survey, to screen for unerupted supernumerary teeth. If no supernumerary teeth are visible during clinical examination the score will be 0.

3.2.1.3 Posterior component

- Mesial movement of first permanent molars:

Arch length is lost when first permanent molars move mesially. Mesial drifting of upper and lower first permanent molars is recorded.

Mesial movement of first permanent molars is recorded only when interproximal caries with loss of the marginal ridge, early loss and/or ankylosis of the primary molars in that quadrant are present.

Upper molars rotate around the larger palatal root, when drifting mesially. The number of mesially rotated upper molars is recorded.

Mesial rotation is confirmed when the extension of an imaginary line between the disto-buccal cusp and the mesio-lingual cusp of the upper molar crosses distal to the contact point of the contralateral first and second primary molar.

Lower molars tip mesially, when drifting. The number of mesially tipped first permanent lower molars is recorded.

When recording mesial tip of the lower molars, the side of the ruler is held parallel to the gingival margins of the lower arch. If the long axis of the lower molar is inclined more acutely than the oblique side of the ruler (i.e. more than 15°) it is scored.

If rotation and/or tipping can't be measured due to unerupted or partially erupted first permanent molars, it is recorded as "not measurable" (X).

Table 1 **Lower first permanent molar inclination (IPION-6)**

Lower first permanent molar inclination	***Score***
Not measurable	X
Long axis ≥ 75° to marginal gingival	0
Long axis < 75° to marginal gingival	1

3.2.1.4 Occlusion

- Overjet:

An increased positive overjet can either be an early sign of a skeletal Class II malocclusion or can be the result of a deleterious sucking habit. Deleterious habits can lead to permanent damage to the occlusion and should probably be intercepted before eruption of the permanent teeth (Ngan & Fields, 1995).

The most prominent incisor overjet is identified and the overjet is recorded in relation to the labial aspect of the incisal edge. When recording the overjet, the ruler is held parallel to the occlusal plane and radial to the line of the arch. The overjet score (0 to 4) is determined by looking at the position of the labial surface of the upper incisor on the ruler. If the labial surface is exactly on the line, the lower score is recorded. If the overjet can't be measured due to exfoliation of the primary incisors, it is recorded as "not measurable".

Table 2 **Overjet (IPION-6)**

Overjet	***Score***
Not measurable	X
0 – 3 mm	0
3.1 – 5 mm	1
5.1 – 7 mm	2
7.1 – 9 mm	3
Greater than 9 mm	4

- Anterior crossbite:

Anterior crossbite of the incisors is often associated with a pseudo Class III and should be treated immediately. Anterior crossbite could cause traumatic occlusion and attrition of the maxillary and mandibular incisors during mastication and should therefore be corrected as early as possible. If one or more incisors or canines are in crossbite, while a positive overbite exists as well, the two scores are summed.

Instructions for scoring anterior crossbite are summarised in Table 3.

Table 3 **Anterior crossbite (IPION-6)**

Anterior crossbite	*Score*
No crossbite	0
One or more teeth edge to edge	0*
One or two teeth in crossbite	2
More than two teeth in crossbite	3

* Edge to edge incisor relationship is regarded normal at six years of age.

- Overbite:

The worst vertical overlap or open bite of any of the four incisors is recorded. Overbite is recorded in relation to the coverage of the lower incisors or the degree of open bite (with the aid of the IPION ruler). If the overbite can't be measured (e.g. exfoliation of the primary incisors), it is recorded as "not measurable".

In a patient with a severe anterior deep bite the lower incisors often cause trauma of the palatal mucosa or the soft tissue attachment palatal of the maxillary incisors during function.

Anterior open bite is associated with abnormal swallowing and deleterious sucking habits, both of which can be treated at this early age.

Table 4 **Overbite (IPION-6)**

Overbite	*Score*
Not measurable	X
≤ two thirds coverage of the lower incisors	0
> two thirds coverage of the lower incisor, but less than full coverage	1
≥ full coverage of the lower incisor	2

Table 5 **Open bite (IPION-6)**

Open bite	*Score*
No open bite	0
≤ 1 mm	1
1.1 – 2 mm	2
2.1 – 3 mm	3
≥ 3.1 mm	4

- Transverse buccal occlusion

The buccal occlusion is recorded for both left and right sides. The fit of the teeth is recorded in the transverse plane. The recording zone is from the first primary molar/first premolar to the last molar. All features are recorded when the teeth are in occlusion.

A crossbite is scored when the buccal cusps of the maxillary posterior teeth are lingual to the mandibular posterior teeth during intercuspation. A scissorsbite is where the palatal cusps of the maxillary posterior teeth are biting buccal to the mandibular posterior teeth. A crossbite tendency is where the maxillary and mandibular posterior teeth are biting in a cusp-to-cusp transverse relationship during intercuspation. The teeth are neither in a full crossbite, nor in scissorsbite.

If left unattended, a functional posterior crossbite may lead to asymmetrical growth at the condyles and permanent facial asymmetry.

***Table 6* Transverse buccal occlusion assessment (IPION-6)**

Transverse buccal occlusion assessment	*Score*
No crossbite	0
Crossbite tendency	1
Single tooth in crossbite	2
More than one tooth in crossbite	3
More than one tooth in scissorsbite	4

3.2.1.5 Soft tissue assessment

- Lip competency:

Incompetent lip seal is scored if the lips are not in contact during rest. Lips are assessed in the rest position and the interlabial gap is measured with the aid of the IPION ruler. Incompetent lip seal is characteristic of patients with chronic nasorespiratory infections and associated mouth breathing. After addressing the aetiology of the nasorespiratory infection or obstruction myofunctional exercises can be introduced to improve lip competency.

Table 7 **Lip position (IPION-6)**

Lip position at rest	***Score***
Lips sealed at rest	0
≤ 4 mm space between lips at rest	1
> 4 mm space between lips at rest	2

3.2.2 IPION-9

The IPION-9 assesses the need for preventive and interceptive orthodontic treatment in 9-year-olds and consists of the following components.

3.2.2.1 Primary component

- Interproximal caries:

Scores are recorded for both the upper and lower primary molars and cuspids as well as for the first permanent molars. Occlusal and interproximal carious lesions are recorded, since they could lead to early loss of teeth and/or influence the stability of available arch length. Scores are noted according to the number of teeth involved if the marginal ridge is still intact (***a score of 1*** for each affected tooth). If the marginal ridge is not intact, ***a score of 2*** is recorded for that specific tooth. A score of 0 indicates that there are no carious lesions present.

- Premature loss of primary teeth:

Premature loss of primary teeth result in space loss in the dental arches. In the IPION-9 only the number of missing second primary molars are scored. A score of 0 is recorded where the secondprimary molars are still present in the dental arches.

- Submerged (ankylosed) teeth:

The teeth on either side of an ankylosed tooth continue to erupt resulting in an increase in alveolar bone height. If the ankylosed tooth is left in place there will be considerably less bone in that area and also the eruption of the permanent successor is usually impeded.
Any primary molar of which the occlusal surface is situated inferior to the occlusal plane is scored.
Only the number of submerged teeth is recorded and in the absence of any submerged teeth the score will be 0.

3.2.2.2 Anterior component

- Active frenum:

The presence of an active frenum is scored (i.e. if the interdental papilla between the upper central incisors blanches when mild to moderate traction is applied to the labial frenum). An active labial frenum is often, but not as a rule, associated with a large midline diastema. If the frenum is normal the score will be 0.

- Supernumerary teeth:

The highest prevalence of supernumerary teeth is in the maxillary midline region. The presence of an unerupted mesiodens can lead to the impaction of the permanent incisors and if erupted can take up unnecessary space and cause crowding. The number of supernumerary teeth present in the mouth mesial to the canines is recorded.

Due to ethical and cost implications, radiographs can not be taken during an epidemiological survey, to screen for unerupted supernumerary teeth. If no supernumerary teeth are visible during clinical examination the score will be 0.

- Diastema

Scores are recorded for the upper anterior segment only. The presence of a pathological diastema is scored and indexed with the aid of the IPION plastic ruler. A diastema of greater than 2 mm is unlikely to close spontaneously during the eruption of the permanent canines and is therefore regarded as "pathological".

Table 8 **Diastema (IPION-9)**

Size of diastema	*Score*
Not measurable	X
≤ 2 mm	0
> 2 mm	1

- Absent permanent incisors

All absent permanent incisors are recorded regardless of the cause. Scores are recorded for both upper and lower anterior segments by counting the number of permanent incisors absent. If one or more primary incisors is still present and the permanent incisor/s is not visible during clinical examination it is regarded as absent. In cases where all eight permanent incisors are present the score will be 0.

3.2.2.3 Posterior component

- Mesial movement of first permanent molars:

Arch length is lost when first permanent molars move mesially. Mesial drifting of upper and lower first permanent molars is recorded.

Mesial movement of first permanent molars is recorded only when interproximal caries with loss of the marginal ridge, early loss and/or ankylosis of the primary molars in that quadrant are present.

Upper molars rotate around the larger palatal root, when drifting mesially. The number of mesially rotated upper molars is recorded. Mesial rotation is confirmed when the extension of an imaginary line between the disto-buccal cusp and the mesio-lingual cusp of the upper molar crosses distal to the contact point of the contralateral first and second primary molar.

Lower molars tip mesially, when drifting. The number of mesially tipped first permanent lower molars is recorded. When recording mesial tip of the lower molars, the side of the ruler is held parallel to the gingival margins of the lower arch. If the long axis of the lower molar is inclined more acutely than the oblique side of the ruler (i.e. more than 15°) it is scored.

If rotation and/or tipping can't be measured due to unerupted or partially erupted first permanent molars, it is recorded as "not measurable" (X).

Table 9 **Lower first permanent molar inclination (IPION-9)**

Lower first permanent molar inclination	***Score***
Not measurable	X
Long axis ≥ 75° to marginal gingiva	0
Long axis < 75° to marginal gingiva	1

- Impeded eruption of first permanent molars:

The number of ***first*** permanent molars not fully erupted into occlusion is noted, whether it was caused by ankylosis, ectopic eruption or any other known or unknown reason. A score of 0 is recorded if all four first permanent molars are fully erupted.

Ectopic eruption of the first permanent molar causes abnormal resorption of the distal root of the second primary molar which will, in many cases, lead to the early loss of the primary tooth.

3.2.2.4 Occlusion

- Overjet:

An increased positive overjet can either be an early sign of a skeletal Class II malocclusion or can be the result of a deleterious sucking habit. Deleterious habits can lead to permanent damage to the occlusion and should probably be intercepted before the eruption of the permanent teeth (Ngan & Fields, 1995).

The most prominent incisor overjet is identified and the overjet is recorded in relation to the labial aspect of the incisal edge. When recording the overjet, the ruler is held parallel to the occlusal plane and radial to the line of the arch. The overjet score (0 to 4) is determined by looking at the position of the labial surface of the upper incisor on the ruler. If the labial surface is exactly on the line, the lower score is recorded. If the overjet can't be measured due to exfoliation of the primary incisors, it is recorded as "not measurable".

Table 10 **Overjet (IPION-9)**

Overjet	*Score*
Not measurable	X
0 – 3 mm	0
3.1 – 5 mm	1
5.1 – 7 mm	2
7.1 – 9 mm	3
Greater than 9 mm	4

- Anterior crossbite (Instructions for scoring summarised in Table 11)

Anterior crossbite of the incisors is often associated with a pseudo Class III. If an anterior functional shift of the mandible exists it should be treated immediately. Anterior crossbite could cause traumatic occlusion and attrition of the maxillary and mandibular incisors during mastication and should therefore be corrected as early as possible.

If one or more incisors or canines are in crossbite, while a positive overbite exists as well, the two scores are summed.

Table 11 **Anterior crossbite (IPION-9)**

Anterior crossbite	*Score*
No crossbite	0
One or more teeth edge to edge	1
One or two teeth in crossbite	2
More than two teeth in crossbite	3

- Overbite

The worst vertical overlap or open bite of any of the four incisors is recorded. Overbite is recorded in relation to the coverage of the lower incisors or the degree of open bite (with the aid of the IPION ruler).

If the overbite can't be measured (e.g. exfoliation of the primary incisors), it is recorded as "not measurable".

An anterior deep bite often restricts the forward growth of the mandible and in severe cases the lower incisors can impinge on the palatal mucosa.

Table 12 **Overbite (IPION-9)**

Overbite	*Score*
Not measurable	X
≤ two thirds coverage of the lower incisors	0
> two thirds coverage of the lower incisor, but less than full coverage	1
≥ full coverage of the lower incisor	2

Table 13 **Open bite (IPION-9)**

Open bite	*Score*
No open bite	0
≤ 1 mm	1
1.1 – 2 mm	2
2.1 – 3 mm	3
≥ 3.1 mm	4

- Antero-posterior molar relationship:

The relationship between the first permanent molars is recorded for both left and right sides. Recordings are made with the teeth in occlusion. A Class I/normal molar relationship is recorded when the mesio-buccal cusp of the upper first permanent molar occludes anywhere between the buccal groove and the tip of the mesial cusp of the opposing lower first permanent molar.

A Class II molar relationship is recorded when the mesio-buccal cusp of the upper first permanent molar occludes anywhere mesial to the tip of the mesial cusp of the opposing lower first permanent molar.

A Class III molar relationship is when the mesio-buccal cusp of the upper first permanent molar occludes anywhere distal to the buccal groove of the opposing lower first permanent molar.

Should one or more first permanent molars be absent or not erupted fully into occlusion, the relationship of the second primary molars are recorded as a flush terminal plane, mild mesial step (<2mm), severe mesial step (≥2mm) or distal step.

A flush terminal plane as well as a mesial step of less than 2 mm are likely to develop into a Class I relationship of the first permanent molars in the permanent dentition, and is therefore regarded as normal for 6-year-olds. A mesial step of 2 mm and more, and a distal step, will most likely develop into a Class III and a Class II first permanent molar relationship in the permanent dentition, respectively (Bishara et al, 1988). In cases with early loss of primary molars, the molar relationship is recorded as "not measurable".

A Class III molar relationship of the first permanent molars and a mesial step of 2mm or more between the second primary molars is recorded only when there is an anterior functional shift of the mandible during closure (i.e. pseudo Class III).

Table 14 **Molar relationship (deciduous molars)**

Molar relationship	*Score*
Not measurable	X
Flush terminal plane	0
Mesial step < 2 mm	0
Mesial step ≥ 2 mm	0 or 5
Distal step	2

Table 15 **Molar relationship (permanent molars)**

Molar relationship	*Score*
Class I / Normal	0
Class III	0 or 5
Class II	2

- Transverse buccal occlusion:

The buccal occlusion is recorded for both left and right sides. The fit of the teeth is recorded in the transverse plane. The recording zone is from the first primary molar/first premolar to the last molar. All features are recorded when the teeth are in occlusion.

A crossbite is scored when the buccal cusps of the maxillary posterior teeth are lingual to the mandibular posterior teeth during intercuspation. A scissorsbite is where the palatal cusps of the maxillary posterior teeth are biting buccal to the mandibular posterior teeth. A crossbite tendency is where the maxillary and mandibular posterior teeth are biting in a cusp-to-cusp transverse relationship during intercuspation. The teeth are neither in a full crossbite, nor in scissorsbite.

If left unattended, a functional posterior crossbite may result in asymmetrical condylar growth and permanent facial asymmetry.

Table 16 **Transverse buccal occlusion (IPION-9)**

Transverse buccal occlusion assessment	*Score*
No crossbite	0
Crossbite tendency	1
Single tooth in crossbite	2
More than one tooth in crossbite	3
More than one tooth in scissorsbite	4

3.2.2.5 Soft tissue assessment

- Lip competency:

Incompetent lip seal is scored if the lips are not in contact during rest. Lips are assessed in the rest position and the interlabial gap is measured with the aid of the IPION ruler. Incompetent lip seal is characteristic of patients with chronic nasorespiratory infections and associated mouth breathing. After addressing the aetiology of the nasorespiratory infection or obstruction myofunctional exercises can be introduced to improve lip competency.

Table 17 **Lip position (IPION-9)**

Lip position at rest	*Score*
Lips sealed at rest	0
≤ 4 mm space between lips at rest	1
> 4 mm space between lips at rest	2

3.3 MATERIALS USED

The following materials were used in this study:

i) A total of 30 dental casts were selected from the records of the Department of Orthodontics, University of Pretoria. Fifteen of these were taken on 6-year olds and the other fifteen on 9-year-olds.

ii) A document describing the components of the indices were compiled and handed out to each of the thirty examiners a few days before measurements were performed.

iii) A set of slides was prepared, and used in a short lecture given to the examiners before measuring up of models commenced.

iv) Two separate data sheets were designed for recording IPION-6 (Addendum A) and IPION-9 (Addendum B) measurements respectively.

v) Plastic IPION rulers were printed.

3.4 RESEARCH METHODOLOGY

This research project consisted of three parts:

i) Part I

A panel of 10 orthodontists took part in a discussion, during which consensus was reached on the suggested weighting factors assigned to individual criteria. The orthodontists were chosen on the grounds of clinical experience and previous involvement with studies on orthodontic epidemiology.

ii) Part II

The reliability (reproducibility) of the indices was tested by a group of 30 people consisting of 10 orthodontists, 10 dentists and 10 oral hygienists. A short introductory lecture on the use of the indices was given, after which they were asked to assess 30 dental casts (15 six-year-olds and 15 nine-year-olds), using the IPION-6 and IPION-9. An index is regarded reliable if a high level of intra- and inter-examiner reproducibility is achieved when using the index.

iii) Part III

The validity of the indices was tested by a group of 5 orthodontists. They were asked to subjectively evaluate each of the 30 dental casts used in Part 2 of this study for preventive- and/or interceptive orthodontic treatment need. Each dental cast had to be assigned to one of three treatment need categories i.e. no need for treatment, moderate need, or definite need. These results, together with the total IPION gold standard score for each cast, were then used to test the validity of these indices. The validity of an index is tested by determining whether it measures what it intends to measure.

3.5 STATISTICAL ANALYSES

The intra-examiner reliability (reproducibility) and agreement between examiners and the gold standard were determined by the statistical method described by Bland and Altman (1986). In this method the agreement is determined by calculating the bias, estimated by the mean difference ($\bar{d}$) and the standard deviation of the differences (s). The limits of agreement are then calculated as follows:

$$\bar{d} - 2s \text{ and } \bar{d} + 2s$$

In the analysis of measurement method comparison data, neither the correlation coefficient nor techniques such as regression analysis are appropriate. Bland and Altman suggested replacing these misleading analyses by a method that is simple both to do and to interpret. Further, the same method may be used to analyse the repeatability of a single measurement method or to compare measurements by two observers.

Kappa statistics were used in the validation of the index.

CHAPTER 4

RESULTS AND DISCUSSION

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CHAPTER 4

RESULTS AND DISCUSSION

4.1 PART I - WEIGHTING FACTORS

4.1.1 Results and discussion of Part I

The aim of the first part of the study was to determine weighting factors for each of the variables measured in the index. Some of these variables play a more important role in the development of malocclusions that can be treated by early preventive- and interceptive orthodontic treatment and should therefore carry more weight. The weighting factor assigned to a specific variable in the IPION-6 (6-year-olds) is not necessarily applicable at 9-years of age (IPION-9).

The results of the consensus opinion of the panel of ten orthodontists are summarised in Table 18 (IPION-6) and Table 19 (IPION-9).

The difference in weighting factors between unilateral and bilateral loss of mandibular primary canines is due to the fact that unilateral loss may lead to midline deviations and dental arch asymmetries (Russell, 1996). If the patient has lost one mandibular primary canine a score of 1 will be given for that variable. This score is then multiplied by a weighting factor of 8, resulting in a weighted score of 8. If a patient, however, has lost both mandibular primary canines, a score of 2 is recorded and then multiplied by the weighting factor of 2. The weighted score will therefore be 4.

A higher weighting factor is also given to caries and early loss of second primary molars compared to first primary molars. It is a well known fact that space is lost more rapidly when second primary molars are lost prematurely or where interproximal caries of these teeth is present (Richardson, 1982b).

In the IPION-6 early loss of second primary molars is given a weight of 4 while in the IPION-9 early loss of maxillary and mandibular second primary molars carry weighting factors of 2 and 3 respectively. The earlier a second primary molar is lost the more space is lost in the dental arch and should therefore have a higher contribution to the total IPION score. Another reason for the lower weight is that missing second primary molars at age nine can be the result of normal exfoliation. Regaining of space following early loss of second primary molars is more difficult in the mandibular arch and it was therefore decided to give a higher weighting factor to early loss of these teeth in the IPION-9.

Because of the fact that carious lesions on primary canines are fairly uncommon and, if present, don't result in severe loss of arch length, caries of maxillary and mandibular primary canines has no weighting factor assigned to it. Interproximal caries of the mesial surface of the first permanent molar, on the other hand, results in rapid loss of arch length and therefore carries a weigthing factor of 4.

There is a continuous eruption of teeth in an occlusal direction with associated growth of the alveolar processes. The cementum of ankylosed teeth is merged to the bone and they loose their ability to erupt. Mesial tipping of first permanent molars with loss of arch length is often evident when second primary molars are ankylosed and should therefore be assigned a higher weighting factor.

An active frenum is often, but not as a rule, associated with a large maxillary midline diastema and has no weighting factor attached to it. A central maxillary diastema of more than 2mm is usually regarded as abnormal or pathological and will probably not close by itself during the eruption of the permanent canines. Al Nimri & Richardson (1997) examined the records of 278 nine-year-old children and reported that the largest upper midline diastema which closed spontaneously was 2.5mm.

A midline diastema of greater than 2 mm (in the early mixed dentition) is unlikely to close spontaneously (Edwards, 1977) and is therefore one of the abnormalities in the occlusion that should be corrected as early as possible. A weighting factor of 4 is given. The Dental Aesthetic Index (DAI) assigns a rounded weight of 3 to a midline diastema (Cons et al, 1986).

Taking of radiographs is not permitted during an epidemiological survey and supernumerary teeth are recorded only when visible in the mouth. Their presence (erupted or unerupted) may cause delayed or abnormal eruption of permanent incisors and also lead to severe space shortage and crowding in the anterior maxillary region. The problem of supernumerary teeth should be addressed as early as possible and has a relatively high weighting factor of 4.

Absent permanent incisors at 9 years of age is either due to early loss as a result of trauma, congenital absence or prolonged retention of deciduous incisors. Space can be lost quite rapidly if the situation is left unattended and a weighting factor of 3 is assigned to this variable.

Relatively high weighting factors of 4 were assigned to rotation of maxillary first permanent molars and mesial tipping of mandibular first permanent molars. Rotation of upper molars and mesial tipping of lower molars are signs of space loss due to either early loss of primary teeth, interproximal carious lesions or ankylosis of primary molars. In a great number of these cases it will be necessary to regain the lost space in order to prevent or reduce the amount of crowding in the later stages of development of the dentition.

Ectopic eruption of first permanent molars may lead to abnormal root resorption of the second primary molars which in turn can result in loss of vitality or even early loss of these primary teeth. The abnormal mesially directed eruption path of the permanent molars will inevitably result in loss of arch length. The eruption has to be redirected or the

second primary molar extracted. This calls for early intervention and a relatively high weighting factor of 4.

An increase in the overjet is often associated with deleterious habits but can also be a sign of a skeletal Class II malocclusion and is assigned a weighting factor of 2 – the same as in the Dental Aesthetic Index (DAI) (Cons et al, 1986). In the Peer Assessment Rating (PAR) Index the overjet score is similar to the overjet in millimetres multiplied by a factor of 2 and has a weighting factor of 6. The overjet score also includes teeth in crossbite (Richmond et al, 1992a).

Anterior crossbite is one of the classic abnormalities in the occlusion where early intervention is essential. The abnormal relationship between the incisors may lead to attrision of the teeth, occlusal trauma and all its side effects, as well as functional mandibular shifts. The latter can present as a pseudo Class III malocclusion which, if left untreated, can eventually develop into a true skeletal Class III. If one or more anterior teeth are in crossbite the patient definitely needs interceptive orthodontic treatment (Proffit & Fields, 1993) and it therefore carries a very high weight of 10.

Posterior crossbites, with an associated functional shift of the mandible on closing, should also be corrected as early as possible. Uncorrected mandibular shifts can produce undesirable growth compensation, dental compensation leading to true asymmetries at a later time, and potentially harmful functional patterns (Fields, 1993).

At age six the anterior overbite is often small because of normal wear of the deciduous incisors. The bite tends to deepen with the exfoliation of the primary molars but the overbite usually decreases with the eruption of the premolars. It can therefore be seen that great variations exist in the overbite during the mixed dentition stage of dental development and a weighting factor of 2 seemed appropriate. This is

the same as the PAR Index weighting factor for overbite (Richmond et al, 1992a).

Anterior open bite is often associated with deleterious habits like abnormal swallowing and thumb sucking. The cause of the open bite should be determined as early as possible and if any associated deleterious habits are present they should be dealt with immediately. Anterior open bite is therefore assigned a relatively high weighting factor of 4 which is the same as the rounded weight in the assessment of anterior open bite in the Dental Aesthetic Index (DAI) (Cons et al, 1986).

During the scoring procedure a clear distinction is made between the importance of the different molar relationships on the developing occlusion and no additional weighting factor is added. The PAR Index (Richmond et al, 1992a) does not attach a weighting factor to the buccal occlusion while the DAI (Cons et al, 1986) assigns a rounded weight of 3 to the antero-posterior molar relation.

Incompetent lip seal is often associated with hypotonic muscle tone or mouth breathing as a result of chronic respiratory obstruction. In many patients this method of breathing persists as a deleterious habit even after removal of the cause of the obstruction. Insufficient lip seal can play a role in the aetiology of malocclusions or aggravate existing malocclusions.

Weighting factors are only taken into account once the statistical analysis of the data is done and there is therefore no need to memorise the details thereof. Variables where no weighting factor is needed are given a factor of 1, which if multiplied by the score for that variable, will have no effect on the value.

Table 18 IPION-6 weighting factors

Description of variable	*Weighting factor*
Caries of maxillary and mandibular primary canines	1
Caries of maxillary and mandibular first primary molars	2
Caries of maxillary and mandibular second primary molars	4
Caries of maxillary and mandibular first permanent molars	4
Early loss of maxillary primary canines	1
Unilateral early loss of mandibular primary canines	8
Bilateral early loss of mandibular primary canines	2
Early loss of maxillary and mandibular first primary molars	2
Early loss of maxillary and mandibular second primary molars	4
Supernumerary teeth	4
Rotation of maxillary first permanent molars	4
Tipping of mandibular first permanent molars	4
Overjet	2
Anterior crossbite	10
Overbite	1
Anterior open bite	4
Posterior crossbite without functional lateral shift of the mandible during closing	1
Posterior crossbite with functional lateral shift of the mandible during closing	10
Lip competency	1

Table 19 IPION-9 weighting factors

Description of variable	*Weighting factor*
Caries of maxillary and mandibular canines	1
Caries of maxillary and mandibular first primary molars	2
Caries of maxillary and mandibular second primary molars	4
Caries of maxillary and mandibular first permanent molars	4
Early loss of maxillary second primary molars	2
Early loss of mandibular second primary molars	3
Submerged (ankylosed) first primary molars	1
Submerged (ankylosed) second primary molars	2
Active frenum	1
Supernumerary teeth	4
Diastema	4
Absent permanent incisors	3
Rotation of maxillary first permanent molars	4
Tipping of mandibular first permanent molars	4
Impeded (ectopic) eruption of first permanent molars	4
Overjet	2
Anterior crossbite	10
Overbite	1
Anterior open bite	4
Molar relationship	1
Posterior crossbite without functional lateral shift of the mandible during closing	1
Posterior crossbite with functional lateral shift of the mandible during closing	10
Lip competency	1

4.2 PART II - RELIABILITY AND AGREEMENT

4.2.1 Intra-examiner reliability (Reproducibility)

Järvinen and Väätäjä (1987) suggest that the term reproducibility rather than reliability should be used when repeated measurements are evaluated. Reproducibility is the ability to reproduce the original ratings or scores when the subject is re-examined by the same (intra-examiner reproducibility) or a different examiner (inter-examiner reproducibility) (Shaw et al, 1991).

The author performed the IPION-6 and IPION-9 on the study models of fifteen six-year-olds and fifteen nine-year-olds respectively. These measurements were repeated two months later and the results tested for reproducibility.

The statistical method described by Bland & Altman (1986) was used and the results showed very good intra-examiner reproducibility for both the IPION-6 and IPION-9. The total weighted scores of the second recording were used as the gold standard to which the results of the thirty examiners were compared.

In the recording of the IPION-6 the total weighted scores of thirteen of the fifteen study models showed no difference when first and second recordings were compared with each other. The scores for the remaining two models were respectively four IPION points higher and lower when measured for the second time (Table 20).

The difference between the mean IPION scores of the two sets of recordings was zero and the standard deviation of the differences was 1.51. The coefficient of repeatability is calculated as follows:

2 x standard deviation = 2 x 1.51 = 3.02.

The range of difference in IPION-6 scores were –4 to 4 and the limits of agreement were calculated as follows:

$\bar{d} - 2s = 0 - (2 \times 1.51) = -3.02$

$\bar{d} + 2s = 0 + (2 \times 1.51) = 3.02$

Table 20 Comparison between first and second IPION-6 recordings

Model NO.	*First recording*	*Second recording*
1	4	4
2	60	60
3	72	72
4	14	18
5	72	72
6	36	36
7	2	2
8	0	0
9	20	20
10	14	10
11	50	50
12	13	13
13	24	24
14	30	30
15	8	8

The results of the IPION-9 showed that the first and second recordings were identical, except for one study model (Table 21), resulting in a difference in mean IPION score of 0.13 and a standard deviation of 0.52. This means that the coefficient of repeatability is 1.04.

The range of difference in IPION-9 scores were 0 to 2 and the limits of agreement were calculated as follows:

$\bar{d} - 2s = 0.13 - (2 \times 0.52) = -0.91$

$\bar{d} + 2s = 0.13 + (2 \times 0.52) = 1.17$

Table 21 Comparison between first and second IPION-9 recordings

Model NO.	*First recording*	*Second recording*
16	7	7
17	6	6
18	10	10
19	22	22
20	5	3
21	2	2
22	21	21
23	20	20
24	55	55
25	15	15
26	7	7
27	7	7
28	12	12
29	16	16
30	14	14

Because of the fact that differing statistical methods were used in earlier studies on orthodontic epidemiological indices it is difficult to make direct comparisons with the results of the current study.

Turner (1990), however, used the Spearman's Ranked Coefficient of Correlation (r_s) as well as the method of Bland and Altman (1986) to determine the intra-examiner reproducibility in her study of the Treatment Priority Index (TPI). The intra-examiner reproducibility of the orthodontist in the study was very good (r_s=0.90). The limits of agreement (Bland and Altman) were –4.02 to 4.61 and the range of differences in paired TPI scores was –3.5 to 9.

Buchanan et al (1993) used the Intra-class Correlation coefficient (Fleiss, 1979) to determine intra-examiner reliability of the Peer Assessment Rating (PAR) Index and the Summers' Occlusal Index (OI). A high level of reliability was found both for the PAR Index (r = 0.94) and the OI (r = 0.95).

4.2.2 Agreement between the gold standard and examiners

Agreement was evaluated by comparing the mean IPION score measured by each of the examiners with that measured by the gold standard. As mentioned earlier different criteria are used in the IPION-6 and IPION-9 and the results were therefore evaluated separately. The mean weighted IPION-6 score of fifteen dental casts was calculated for the gold standard and then subtracted from that measured by each of the 30 examiners. The same method was used for the fifteen dental casts of nine-year-olds (IPION-9). The mean weighted IPION-6 and IPION-9 scores of the gold standard were 27.93 and 14.47 respectively.

The group of examiners consisted of ten orthodontists (examiners 1 to 10), ten general dental practitioners (examiners 11 to 20) and ten oral hygienists (examiners 21 to 30).

Figure 2 Differences in the mean IPION-6 scores of the gold standard and each of the 30 examiners

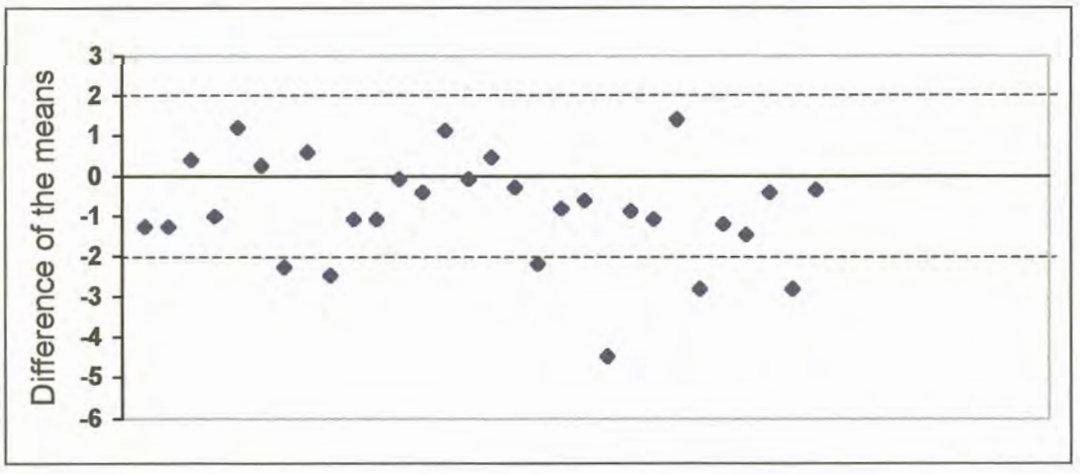


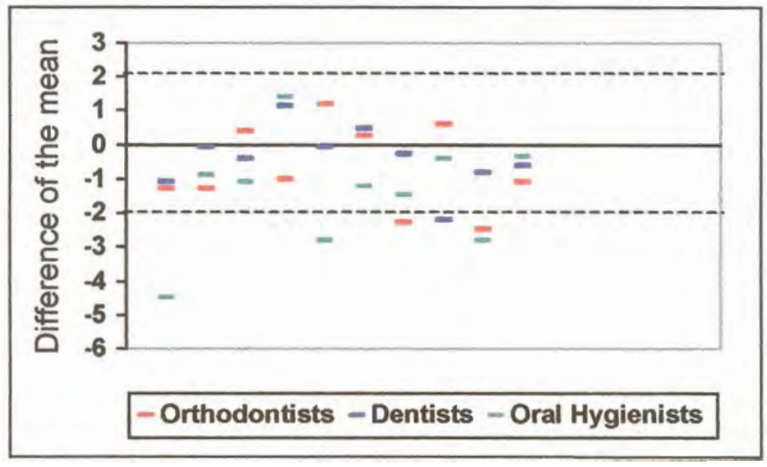
Table 22 Comparison of examiners' IPION-6 scores with the gold standard

Examiner number	*Mean IPION-6 Score*	*Difference between examiner's score and gold standard*
Gold standard	27.93	-
1	26.67	-1.26
2	26.67	-1.26
3	28.33	0.40
4	26.93	-1.00
5	29.13	1.20
6	28.20	0.27
7	25.67	-2.26
8	28.53	0.60
9	25.47	-2.46
10	26.87	-1.06
11	26.87	-1.06
12	27.87	-0.06
13	27.53	-0.40
14	29.07	1.14
15	27.87	-0.06
16	28.40	0.47
17	27.67	-0.26
18	25.73	-2.20
19	27.13	-0.80
20	27.33	-0.60
21	23.47	-4.46
22	27.07	-0.86
23	26.87	-1.06
24	29.33	1.40
25	25.13	-2.80
26	26.73	-1.20
27	26.47	-1.46
28	27.53	-0.40
29	25.13	-2.80
30	27.60	-0.33

The differences in the mean weighted IPION-6 scores are given in table 22 and the distribution is illustrated in figure 2.

In figure 2 the x-axis (0) represents the gold standard and the permitted error of 2 IPION points is indicated by the two dotted lines. It is clear that six of the 30 examiners had mean scores that fell outside the limits of error. This group consisted of two orthodontists, one dentist and three oral hygienists (Figure 3). It was decided that an error of two IPION points would be reasonable and is the same as that used in the calibration of persons in the use of the Peer Assessment Rating (PAR) Index. If an individual's mean IPION score falls within 2 points of that of the gold standard he/she will be calibrated in the use of the index.

Figure 3 Differences in the mean IPION-6 scores of the gold standard and individual examiners according to examiner groups



The mean differences in the IPION-6 scores of the gold standard and each of the three examiner groups are shown in Figure 4 and Table 23. It is clear that all three examiner groups showed very good agreement with the gold standard and that the mean differences are within the margins of permitted error (2 IPION-6 points).

Figure 4 Mean differences in the IPION-6 scores of each of the examiner groups and the gold standard

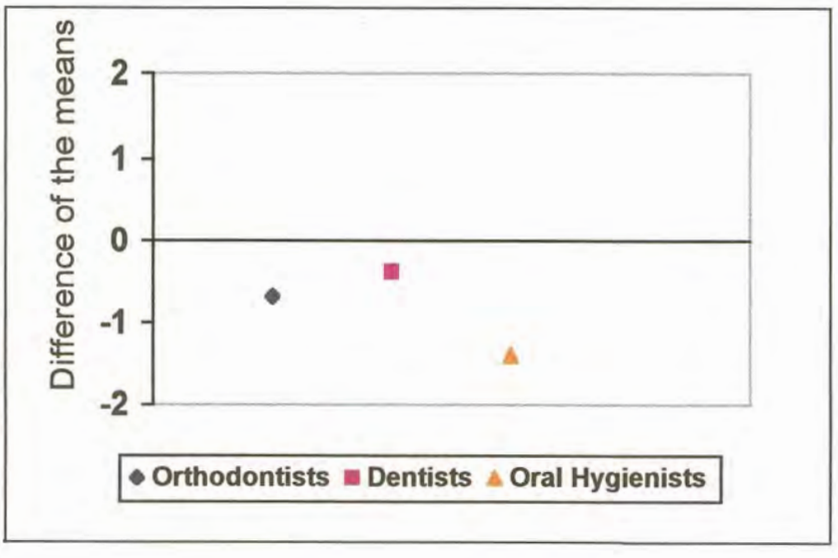


Table 23 Mean IPION-6 scores of the three examiner groups as well as the difference between these means and that of the gold standard

Examiner group	*Mean IPION-6 score*	*Difference in mean*
Orthodontists	27.25	-0.68
Dentists	27.55	-0.38
Oral Hygienists	26.53	-1.4

The statistical methods for assessing agreement between two methods of clinical measurement described by Bland & Altman (1986) may also be used to analyse the repeatability of a single measurement method or to compare measurements by two observers.

Agreement can be summarised by calculating the bias, estimated by the mean difference ($\bar{d}$) and the standard deviation of the differences (s). For examiner 12, for example, the mean difference is –0.06 (Figure 5).

The mean difference is calculated by subtracting the mean IPION-6 score measured by the gold standard from that measured by the examiner. We would expect most of the differences measured for each of the 15 study models to lie between $\bar{d}$ - 2s and $\bar{d}$ + 2s. If the differences are normally distributed (Gaussian), 95% of differences will lie between these limits (or, more precisely, between $\bar{d}$ – 1.96s and $\bar{d}$ + 1.96s). Such differences are likely to follow a normal distribution because a lot of the variation between subjects has been removed and only the measurement error is left.

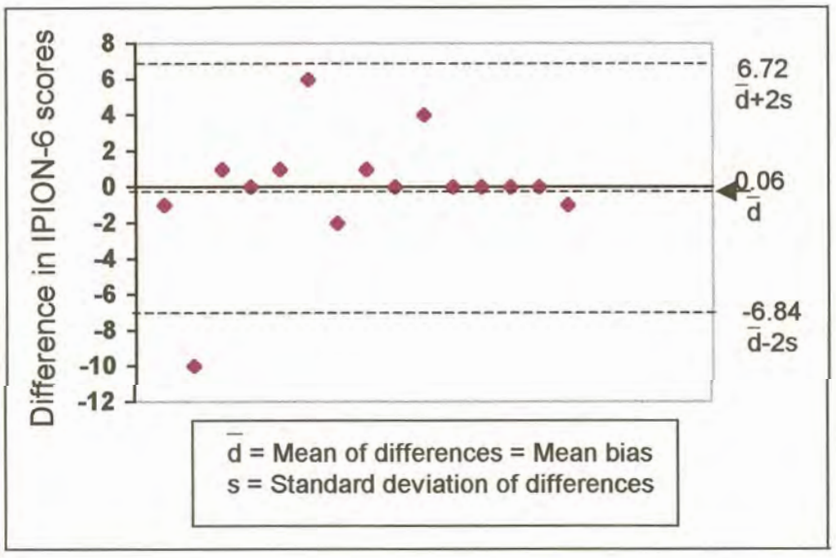
The measurements themselves do not have to follow a normal distribution, and often they will not (Bland & Altman, 1986).

The limits of agreement for examiner 12 can be calculated as follows:

$\bar{d} - 2s = -0.06 - (2 \times 3.39) = -6.84$

$\bar{d} + 2s = -0.06 + (2 \times 3.39) = 6.72$

Figure 5 Comparison of examiner 12 with the gold standard IPION-6

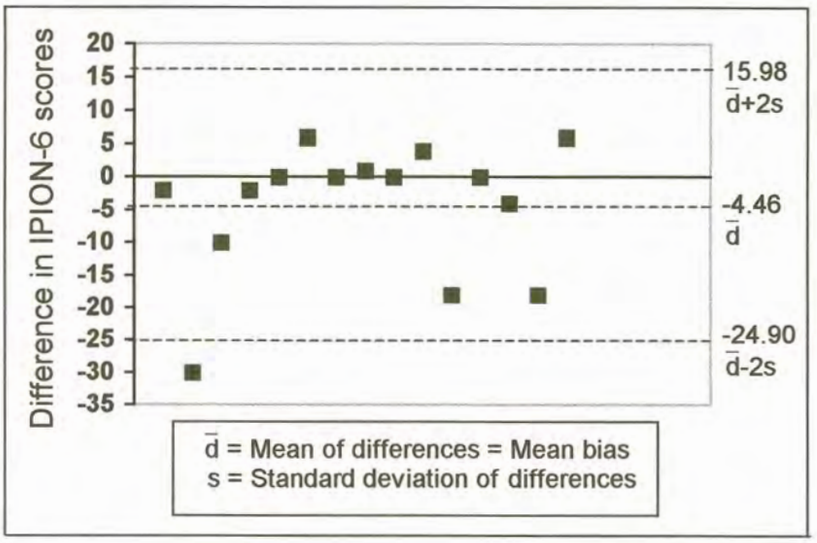


It is clear that examiner 12 showed excellent agreement with the gold standard. Examiner 21, on the other hand, is an example of an examiner that showed poor agreement with the gold standard (Figure 6). The limits of agreement for examiner 21 are calculated as follows:

$\bar{d} - 2s = -4.46 - (2 \times 10.22) = -24.90$

$\bar{d} + 2s = -4.46 + (2 \times 10.22) = 15.98$

Figure 6 Comparison of examiner 21 with the gold standard IPION-6



Although examiner 21 scored eleven of the fifteen study models within 6 IPION-6 points of the gold standard, the scores of the remaining four differed between ten and thirty points. These four measurements were all lower than that recorded by the gold standard, which in the end led to a mean bias of –4.46.

During a calibration exercise examiner 21 will not be calibrated in the use of the index because of the fact that the mean difference of –4.46 falls outside the permitted limits of error.

The trends observed in the results of the IPION-9 differ somewhat from those of the IPION-6. The examiners of whom the difference of the mean IPION scores fell outside the margins of error (2 IPION points) were not the same for the two indices. Figure 7 shows that only two examiners recorded mean IPION-9 scores that differed more than two points from the gold standard. The mean IPION-9 scores and mean differences with the gold standard are summarised in table 24.

The two examiners (14 and 20) that didn't measure within the margins of error were both dentists (Figure 8). They both scored on average 2.2 points higher than the gold standard (Table 24), which is only marginally outside the permitted limit of error.

The results showed that both the IPION-6 and IPION-9 are repeatable with a high degree of agreement between examiners and the gold standard. More intensive training in the use of the indices will most probably improve agreement even further.

Figure 7 Differences in the mean IPION-9 scores of the gold standard and each of the 30 examiners

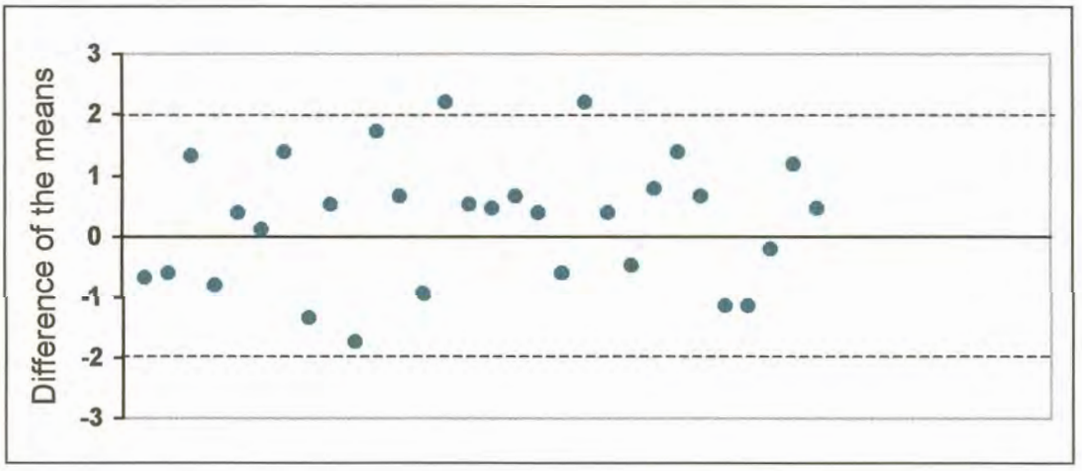
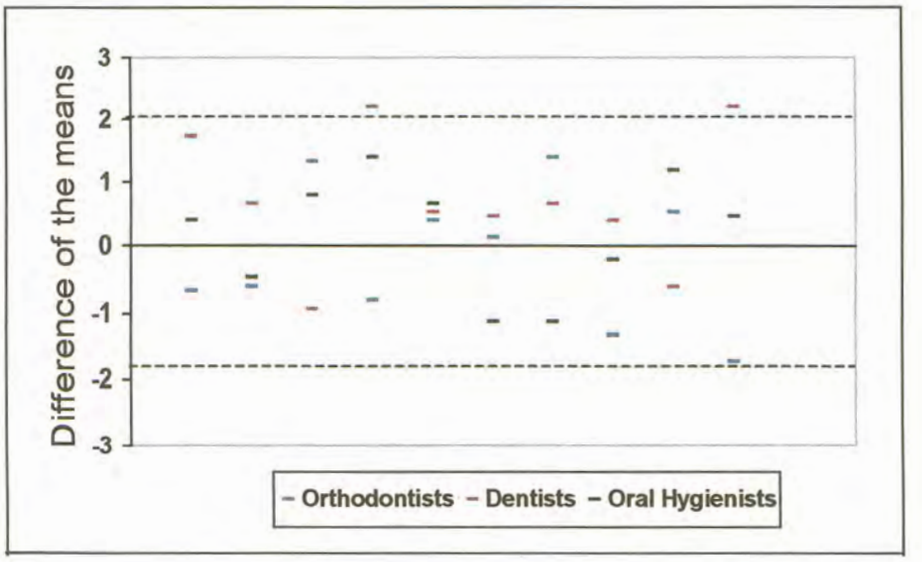


Table 24 Comparison of examiners' IPION-9 scores with the gold standard

Examiner number	*Mean IPION-9 Score*	*Difference between examiner's score and gold standard*
Gold standard	14.47	-
1	13.80	-0.67
2	13.87	-0.60
3	15.80	1.33
4	13.67	-0.80
5	14.87	0.40
6	14.60	0.13
7	15.87	1.40
8	13.13	-1.34
9	15.00	0.53
10	12.73	-1.74
11	16.20	1.73
12	15.13	0.66
13	13.53	-0.94
14	16.67	2.20
15	15.00	0.53
16	14.93	0.46
17	15.13	0.66
18	14.87	0.40
19	13.87	-0.60
20	16.67	2.20
21	14.87	0.40
22	14.00	-0.47
23	15.27	0.80
24	15.87	1.40
25	15.13	0.66
26	13.33	-1.14
27	13.33	-1.14
28	14.27	-0.20
29	15.67	1.20
30	14.93	0.46

Figure 8 Differences in the mean IPION-9 scores of the gold standard and individual examiners according to examiner groups



The mean differences in the IPION-9 scores of the gold standard and each of the three examiner groups are given in Figure 9 and Table 25. It is clear that all three examiner groups, as was the case with the IPION-6, showed very good agreement with the gold standard and that the mean differences are within the margins of permitted error (2 IPION-9 points).

Figure 9 Mean differences in the IPION-9 scores of each of the examiner groups and the gold standard

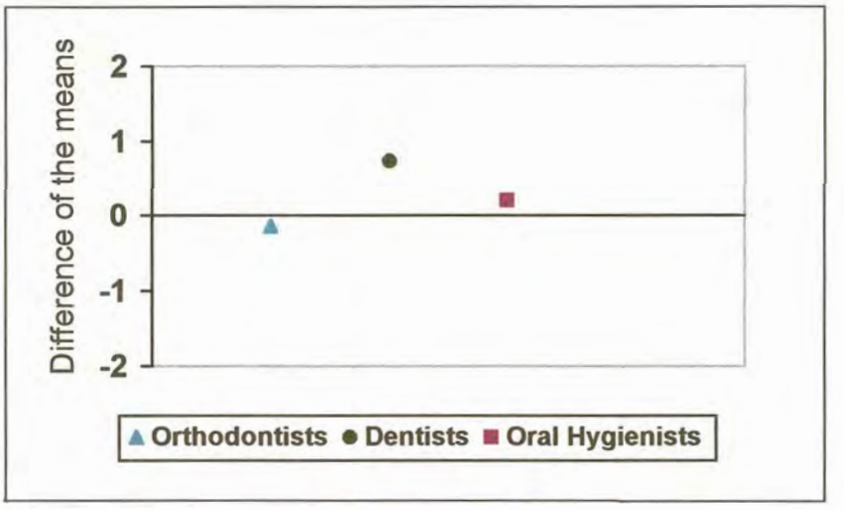


Table 25 Mean IPION-9 scores of the three examiner groups as well as the difference between these means and that of the gold standard

Examiner group	*Mean IPION-9 score*	*Difference in mean*
Orthodontists	14.33	-0.14
Dentists	15.20	0.73
Oral Hygienists	14.67	0.20

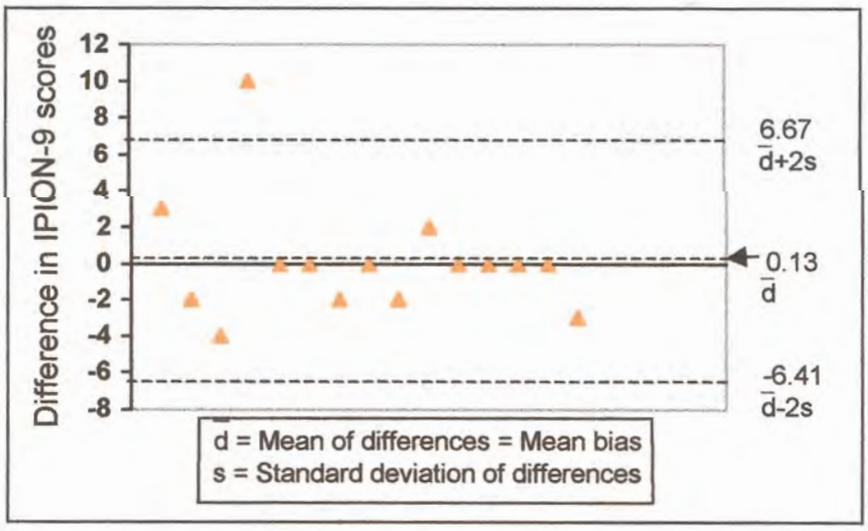
In the evaluation of the IPION-9 examiner 6 showed the best agreement with the gold standard. The limits of agreement for examiner 6 can be calculated as follows:

$$\bar{d} - 2s = 0.13 - (2 \times 3.27) = -6.41$$

$$\bar{d} + 2s = 0.13 + (2 \times 3.27) = 6.67$$

In figure 10 it is evident that all the measurements performed by examiner six, except one, were within the limits of agreement. During a calibration procedure this examiner will definitely be calibrated in the use of the index because of the excellent agreement with the gold standard.

Figure 10 Comparison of examiner 6 with the gold standard IPION-9



Although the two examiners (14 and 20) who's IPION-9 scores differed more than 2 IPION points from that of the gold standard had the same mean difference of 2.20, their individual measurements showed little similarity (Figures 11 & 12 and Table 26).

Table 26 Comparison between the IPION-9 scores of the gold standard and examiners 14 and 20

Model NO.	*Gold standard*	*Examiner 14*	*Examiner 20*
16	7	17	10
17	6	7	12
18	10	10	25
19	22	32	22
20	3	3	3
21	2	4	2
22	21	20	19
23	20	20	20
24	55	52	58
25	15	19	19
26	7	7	9
27	7	7	7
28	12	20	12
29	16	17	17
30	14	15	15

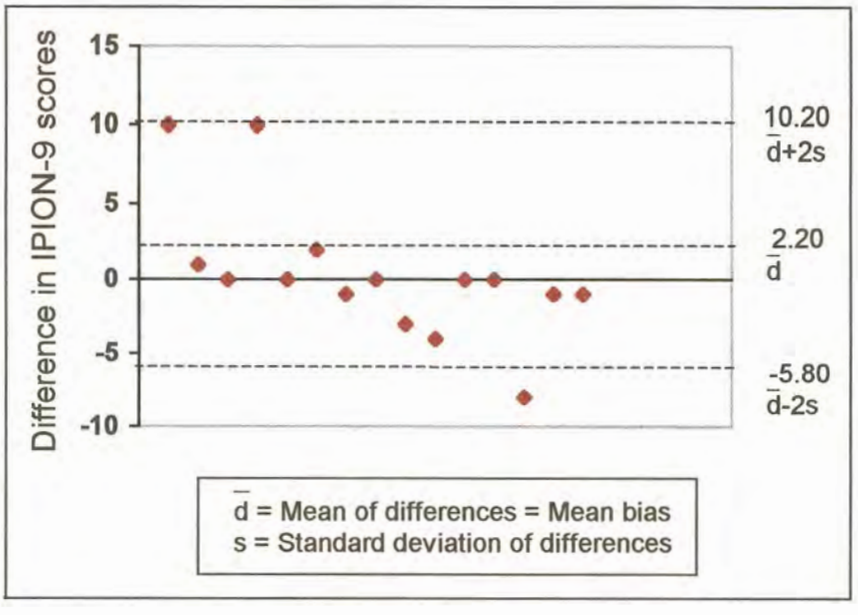
Examiner fourteen's results showed that the IPION-9 scores of twelve of the fifteen study models measured were within 4 IPION points of the gold standard, whereas, examiner 20 scored thirteen out of the fifteen models within 4 IPION points of the gold standard.

The limits of agreement for examiner 14 are calculated as follows:

$\bar{d} - 2s = 2.20 - (2 \times 4.00) = -5.80$

$\bar{d} + 2s = 2.20 + (2 \times 4.00) = 10.20$

Figure 11 Comparison of examiner 14 with the gold standard IPION-9



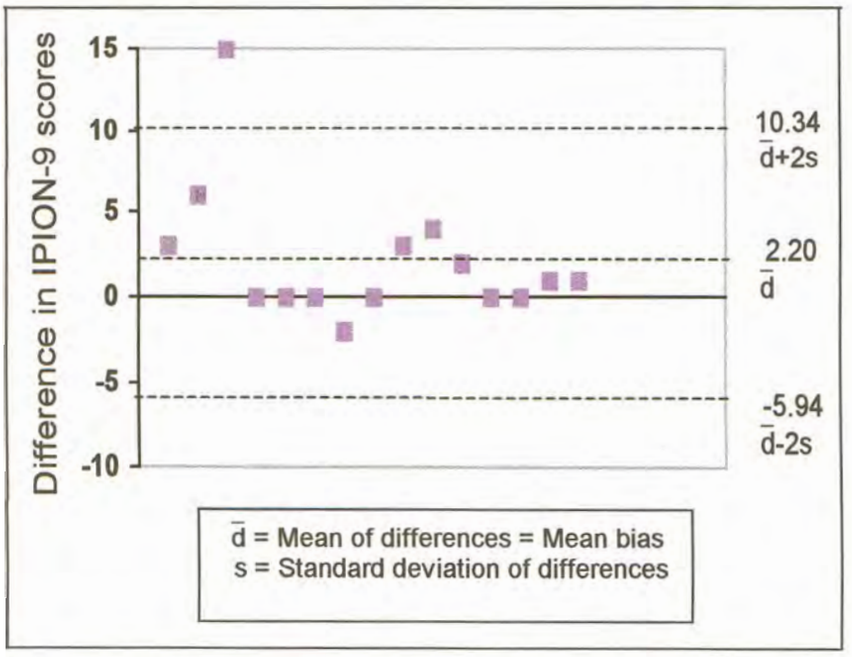
The limits of agreement for examiner 20 are as follows:

$\bar{d} - 2s = 2.20 - (2 \times 4.07) = -5.94$

$\bar{d} + 2s = 2.20 + (2 \times 4.07) = 10.34$

In this study a bias of two IPION points was regarded as being within acceptable limits. These margins can, however, be changed if it is felt that two IPION points is too great an error to be clinically acceptable. The opposite is also true and it might even be decided to increase the limits of error. In that case the mean IPION-9 scores of examiners 14 and 20 will also fall within the permitted range.

Figure 12 Comparison of examiner 20 with the gold standard IPION-9



When studying orthodontists' ability to estimate the need for treatment by using certain indices or clinical criteria, relatively high degrees of intra- and inter-examiner reproducibility have been reported (Grewe & Hagan, 1972; Bowden & Davies, 1975).

Bland and Altman (1986) have questioned the statistical methods for assessing agreement between clinical measurements. They suggested that these assessments are often analysed inappropriately using correlation coefficients which lead to misleading conclusions from experimental data.

As an alternative they suggested the simple method that was used in the current study. The majority of studies done to determine the reliability (reproducibility) of existing orthodontic indices, however, made use of correlation coefficients and it is therefore difficult to compare the results with that of the current study.

Turner (1990) used the method described by Bland and Altman (1986) to determine the bias for the Treatment Priority Index (TPI). For all the examiners in the study, the range of differences in paired TPI scores extended beyond the value $\bar{d} \pm 2s$ showing a high level of inconsistency in scoring the TPI. This is in contrast with the findings of the present study which showed good agreement for orthodontists, dentists as well as oral hygienists in scoring the Index for Preventive and Interceptive Orthodontic Needs (IPION).

Richmond et al (1992a) made use of the Intraclass Correlation Coefficient of Reliability (Fleiss, 1979) in the development of the Peer Assessment Rating (PAR) Index. The results showed excellent agreement between examiners (R = 0.91). A study using the Malocclusion Severity Index (MSI) reported inter-examiner reproducibility of between 0.84 and 0.89 with the Pearson's Product Moment Coefficient (Hill, 1992).

4.3 PART III - VALIDITY AND CUT-OFF POINTS

4.3.1 Validity and determination of cut-off points

Validity is one of the ideal properties of an index and can be defined as the ability of an index to measure that which it purports to measure (Shaw et al, 1991).

Kappa statistics were used to determine the validity of the Index for Preventive and Interceptive Orthodontic Needs (IPION). Five orthodontists were asked to subjectively rate each of the thirty study models used in this study for preventive- and/or interceptive orthodontic treatment need.

Each of the study models were placed into one of the following categories:

1 = No treatment need

2 = Moderate treatment need

3 = Definite treatment need

The results were tabulated and from these tables the modus for each study model was determined and cut-off points for the three treatment need categories were identified.

The modus of the results of the subjective opinions of the five orthodontists for each study model are summarised in Tables 27 (IPION-6) and 28 (IPION-9).

Table 27 Results of the subjective opinion of 5 orthodontists as well as the gold standard IPION-6 scores

Model NO.	*Modus of subjective opinions*	*Gold standard IPION-6 score*
1	1	4
2	3	60
3	3	72
4	3	18
5	3	72
6	3	36
7	1	2
8	1	0
9	3	20
10	3	10
11	3	50
12	2	13
13	3	24
14	3	30
15	2	8

Table 28 Results of the subjective opinion of 5 orthodontists as well as the gold standard IPION-9 scores

Model NO.	*Modus of subjective opinions*	*Gold standard IPION-9 score*
16	1	7
17	2	6
18	2	10
19	3	22
20	2	3
21	1	2
22	3	21
23	3	20
24	3	55
25	3	15
26	2	7
27	2	7
28	2	12
29	3	16
30	2	14

The orthodontists didn't always agree in their opinion of preventive and/or interceptive treatment need. This is in accordance with the findings of other studies of existing orthodontic indices (Shaw et al, 1991; Hill, 1992; Richmond et al, 1992a; Richmond et al, 1995).

The gold standard IPION scores were compared with the treatment need category (modus of the subjective opinion of the five orthodontists) in order to identify possible cut-off points for the three treatment need categories. Various combinations of cut-off points were evaluated and compared with the subjective treatment need classification until the best combinations were found. Two possible sets of combinations were identified for the IPION-6 and only one for the IPION-9 (Table 29).

The cut-off points for the two indices were found to be very similar and in order to simplify the interpretation of the total IPION scores it was decided to adopt the IPION-9 cut-off points for both indices.

Table 29 Possible combinations of cut-off points

	No treatment need (1)	*Moderate treatment need (2)*	*Definite treatment need (3)*
IPION-6 (First combination)	0 – 4	5 – 13	14 +
IPION-6 (Second combination)	0 – 7	8 – 17	18 +
IPION-9	0 – 5	6 – 14	15 +

In evaluating the validity of the indices each of the study models was classified into one of the three treatment need categories according to their gold standard IPION score. This was then compared with the modus of the subjective opinion of the five orthodontists and subjected to statistical analysis using Kappa statistics.

The results of the IPION-6 showed a kappa value of 0.88 for the two possible IPION-6 combinations ($p < 0.0001$). A 93.3% agreement was found. The IPION-9 had a kappa value of 0.78 ($p < 0.0001$) and agreement of 86.67%. Because of the fact that the cut-off points of the IPION-6 and IPION-9 were found to be very similar, the results of the IPION-6 were then compared to the IPION-9 cut-off points and analysed using Kappa statistics. The kappa value was calculated as 0.88 and it was therefore concluded that the IPION-9 cut-off points could be applied to both indices. This would simplify the interpretation of the results during an epidemiological survey.

Landis and Koch (1977) have characterised different ranges of values for kappa with respect to the degree of agreement they suggest. For most purposes, values greater than 0.75 may be taken to represent excellent agreement beyond chance, values below 0.40 may be taken to represent poor agreement beyond chance, and values between 0.40 and 0.75 may be taken to represent fair to good agreement beyond chance.
The results of the current study show that excellent agreement was achieved in the validation of both the IPION-6 and IPION-9.

The cut-off points described above are not rigid and can be changed to adapt to varying needs and availability of funds. According to Salzmann (1968), an index of the need for orthodontic treatment has to be able to distinguish patients with the highest scores and priority of treatment from those with lower scores and a less urgent need for treatment. For this purpose, a cut-off point or cut-off points must be determined. If for example *N* children have some kind of malocclusion but resources permit the treatment of *n* children only, the priority of treatment should be given to the children with the highest scores in decreasing order, until *n* children are included (Järvinen and Väätäjä, 1987).

Jenny et al (1993) described a study that established a handicapping malocclusion cut-off score. Orthodontic examiners with experience in screening for occlusal handicap in a public programme were asked to separate handicapping from non-handicapping occlusal conditions on a sample of study models. Dental Aesthetic Index (DAI) scores were calculated for each model. By correlating orthodontists' decisions with DAI scores a cut-off point was established. The DAI cut-off points were later refined by Jenny and Cons (1996).

Jenny and Cons (1996) mentioned in their study that although the Dental Aesthetic Index (DAI) scale has decision points separating different levels of orthodontic treatment need, DAI scores can be rank ordered on a continuous scale from 13 to 80 or higher. This continuous scale makes the DAI sensitive enough to differentiate cases with greater or lesser need for treatment within severity levels. Decision points for eligibility to receive treatment in publicly funded programs can be modified to meet available resources. The same principles could be applied to the IPION if such a need should arise.

Carlos (1970) criticised the method of using a panel assessment to validate an index because it was felt that the judgement of the clinician is not independent of the index being evaluated and that the information upon which the judgement is based, and the information which is obtained with the index is usually the same. Nevertheless, it is really the only method currently available given our lack of knowledge as regards the effect of any particular trait of malocclusion on dental health (Buchanan et al, 1993). Many studies have therefore used the consensus of several experienced orthodontists to compare with the results of the index (Salzmann, 1968; Summers, 1971; Jenny et al, 1983; Richmond et al, 1995).

Richmond et al (1995) concluded that it remains doubtful whether an index can be validated against subjective opinion. Need for treatment may only be assessed in absolute terms with accurate information regarding the long term effects of malocclusions. Currently this information is unavailable. However, in the absence of clear evidence it seems reasonable to introduce a structured index to enable an uniform approach to assess treatment need, which can be modified in the light of new evidence.

As was the case with the reproducibility and agreement part of the current study, it was difficult to draw direct comparisons with previous studies because of the different statistical methods used to evaluate validity.

Buchanan et al (1993) studied the validity of the Peer Assessment Rating (PAR) Index and Summers' Occlusal Index with the Spearman Rank Correlation Coefficient and found good correlation for both indices. In another validation study of the PAR Index, Pearson's correlation coefficient was used (DeGuzman et al, 1995).

Another feature of previous validity studies is the fact that the examiners didn't always agree as to what constituted a need for treatment. Richmond et al (1995) reported that the mean scores for a panel of dentists correlated only moderately with the dental health component of the Index of Orthodontic Treatment Need (IOTN) but that the correlation may have been better if the agreement between the panel of examiners was more consistent. Shaw et al (1991) found that the panel in their study of the IOTN were extremely divided as to what constituted treatment need for dental health, with very low levels of agreement between judges and even from the same judge. Despite this, the correlation between the dental health component and the collective view of the panel was reasonably high, although agreement between the panel and the aesthetic component of IOTN was higher. Hill (1992), in a study on the Malocclusion Severity Index (MSI), reported a poor degree of correlation when each of three consultant orthodontists' subjective rankings of 50 study casts was compared with the others in turn.

These comments are in accordance with the findings of the current study on the development of the Index for Preventive and Interceptive Orthodontic Needs (IPION). Although the kappa values showed excellent agreement for the index, the five orthodontists were not consistent in their evaluation of individual study models.

CHAPTER 5

CONCLUSIONS

The National Oral Health Policy for South Africa (Department of Health,1999) clearly states that the rendering of Oral Health Services in South Africa must be underpinned by the fundamental principles of Primary Health Care which should include inter alia:

- Accessibility of basic oral health services to all citizens.
- A continued commitment to the improvement of oral health through promotion and prevention.
- A commitment to distribute resources equitably.

The results of the 1988/89 National Oral Health Survey showed that 29% of 12-year-old South African schoolchildren are in need of some form of orthodontic treatment (Briedenhann et al, 1994). The treatment need varies from minor treatment to urgent treatment for the worst malocclusions. Many of these problems are the result of dental caries, tooth loss or deleterious habits during the early childhood years. In view of the extent of the problem, the cost of treatment for conventional orthodontic care and the requirements of the Primary Health Care Approach, there might be great benefits in a screening procedure specifically and exclusively devised to identify children who would benefit from interceptive orthodontics. This would be at its best in child groups who, for one reason or another, are deprived of conventional orthodontic care and where orthodontic manpower deficiencies militate against a ready solution. Conventional screening for malocclusion would be likely to generate a demand for appliance therapy which in most areas could not be met under present circumstances (Al Nimri and Richardson, 1997). There is more than enough proof in the literature to show that early intervention of certain malocclusions can simplify, or in some cases even eliminate, comprehensive orthodontic treatment at a later stage.

The use of the IPION in school dental programs and provincial and national oral health surveys can be a useful tool in determining the need for preventive and interceptive orthodontic treatment needs among six- and nine-year-old schoolchildren. It is therefore important to include these age groups in screening examinations during such surveys. The results will serve to identify those individuals in urgent need of early orthodontic intervention and will also assist healthcare authorities in planning the distribution of available resources.

The National Oral Health Policy for South Africa (Department of Health, 1999), also makes provision for the implementation of Water Fluoridation in South Africa. With the introduction of water fluoridation and the subsequent reduction in the prevalence of dental caries, more emphasis should be placed on prevention and interception in orthodontics and more funds should be made available in order to establish preventive and interceptive orthodontic services.

This study has shown that the IPION is both reproducible and valid and the results compare favourably with that of existing orthodontic indices. This index is unique in that it was specifically developed to identify the need for preventive and interceptive orthodontic treatment. In the light of the world-wide emphasis on primary health care, especially in developing countries like South Africa, it seemed appropriate to design a practical and easy to use tool for determining the need for early orthodontic intervention.

In line with the Primary Health Care Approach and linked to the shortage of dentists in many developing countries the results of the study also indicate that other oral health personnel, such as dental therapists and oral hygienists, could be trained and calibrated in the use of the index. This will increase the available manpower during surveys and also result in greater efficiency.

The results reported in this study will serve as a foundation for future studies on the reliability and validity of the index. The study models used in this study were taken from the records of the Department of Orthodontics, University of Pretoria, and was thus limited to patients who reported for orthodontic treatment. Future studies can be planned on larger numbers of subjects which are also more representative of the general population at ages six and nine.

It is expected that the Index for Preventive and Interceptive Orthodontic Needs (IPION) will contribute greatly to the development of preventive and interceptive orthodontic programs and that it will serve to convince the authorities that orthodontics should form an integral part of primary oral health care. Most of all it is hoped that the fruits of this research will be enjoyed by those in whose lives it can make a difference – the patients.