A CEPHALOMETRIC AND DENTAL ANALYSIS OF TREATMENT OUTCOMES OF UNILATERAL CLEFT LIP AND PALATE CHILDREN TREATED AT THE RED CROSS CHILDREN'S HOSPITAL

by

DR. SALIM KASKAR

A thesis submitted in partial fulfilment of the requirements for the degree of Magister Chirurgiae Dentium in Orthodontics in the Faculty of Dentistry, University of the Western Cape.

DECEMBER 2000

SUPERVISOR: DR. HAYDN BELLARDIE

DECLARATION

I,….. **SALIM KASKAR**…..declare that this thesis entitled

A CEPHALOMETRIC AND DENTAL ANALYSIS OF TREATMENT OUTCOMES OF UNILATERAL CLEFT LIP AND PALATE CHILDREN TREATED AT THE RED CROSS CHILDREN'S HOSPITAL

is my own work and that all sources have been accurately reported and acknowledged by means of references, and that this document has not been previously in its entirety or in part been submitted at any university in order to obtain an academic qualification.

Signed: …………………………

ACKNOWLEDGMENTS

I wish to acknowledge my sincere gratitude to the following people for their assistance in this research report:

1. Dr. Haydn Bellardie, my supervisor, for developing my interest in cleft palate research and for his guidance and assistance in this study.
2. Miss K Crombie for her assistance in obtaining the records.
3. A. Rauf Sayed for his advice and assistance with the statistical analyses.
4. I am indebted to the patients who made this study possible.
5. Yasmin Omar and Mohammed Meer for their advice and assistance with the use of the Autocad 2000 programme.
6. To my parents for their support and assistance which made this study possible.

DEDICATION

This thesis is dedicated

to my wife, Shabnum and children, Amina and Mohammed

for their patience, love and support

which made this thesis possible.

ABSTRACT

This study was a cephalometric and dental investigation of the treatment outcomes of UCLP children treated at the Red Cross Children's Hospital (RCCH) with respect to craniofacial morphology and dental arch relationship. The quality of the outcome for the RCCH group was compared with the outcomes reported for the Six-Centre International Study (Mølsted et al., 1992; Mars et al., 1992). The sample consisted of 20 (11 females, 9 males) consecutively treated UCLP children who had cephalometric and dental records taken between the ages of 8 to 11years (mean 10.13 ± 1.2 years). The cephalometric analysis described by Mølsted et al. (1992) was used to evaluate the skeletal and soft tissue morphology. The quality of the dental arch relationship was measured according to the Goslon Yardstick (Mars et al., 1987).

The treatment outcome of children treated at the RCCH was evaluated with respect to craniofacial form and dental arch relationship. When comparing the mean cephalometric skeletal parameters of the RCCH to the six centres in the Eurocleft study, a significant difference was found between the RCCH group and centre D for most of the variables. A significant increase in the upper incisor inclination and maxillary inclination was found in the RCCH patients compared to the European centres. The difference in the soft tissue parameters was limited to the relative protrusion of the nose and the sagittal soft tissue variable sss-ns-pgs.

The analysis of the Goslon scores showed a significant difference between the RCCH group and centres C, D, and F. According to the Goslon score, 85% of the RCCH patients had good to satisfactory dental arch relationship, which was comparable to that recorded for centres A(92%), B(89%) and C(94).

In conclusion, the results of the cephalometric analysis and the Goslon Yardstick showed a significant difference between the RCCH group and centre D. The Goslon score indicated good quality of the dental arch relationship, which faired favourably with the better centres in the Six Centre Study.

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CHAPTER ONE

1. INTRODUCTION

The range of outcome for the surgical repair of cleft lip and palate (CLP) can be considerable and may be related to particular surgical techniques, the skill of individual surgeons, or programs of surgery within different treatment centres. Few if any centres conform to the same approach in surgical technique, timing, or sequence and ancillary interventions such as presurgical orthopaedics, orthodontics, speech therapy and secondary operations. At a meeting on early treatment of cleft lip and palate, 34 teams presented their programs of treatment and produced 34 different programs (Hotz, 1986). The Eurocleft Biomed II Project currently consists of 178 European CLP teams with 171 different treatment protocols for unilateral cleft lip and palate (UCLP) alone (Semb and Shaw, 1998). With such controversy and confusion, clinicians face the impossible task of selecting precise programs of care that offer the best overall chances of success for their patients.

Various methods for evaluating treatment results have been discussed by Roberts et al. (1991) ranging from anecdotal case reports to randomised controlled trials. Intercentre studies offer particular advantages in CLP research because they allow direct comparisons of outcome of primary surgery together with other major components of the treatment program at respective centres. Major contrasts in the type of treatment and the delivery of care as a whole may be examined. Disparities in outcome between centres provide the basis for more detailed prospective trials, which may in the long term improve results even in the better centres. Furthermore, when the methodology employed is well documented and detailed results are published, other centres have an opportunity to audit and compare their own treatment outcomes with the published data.

The outcome of cleft treatment can be assessed in terms of dental arch and skeletal relationships, success of alveolar bone grafting, facial aesthetics, speech and hearing and psychological status together with patient satisfaction. The aim of this study is to evaluate the treatment outcomes with respect to craniofacial and dental morphology in UCLP children treated at the Red Cross Children's Hospital (RCCH).

CHAPTER TWO

2. LITERATURE REVIEW

Many investigations have been conducted on the incidence of cleft lip and palate, the surgical repair of such anomalies and the possible effects of both the cleft and surgery on the craniofacial morphology and dentition. Abnormal facial and maxillary growth is a common finding in many patients with repaired complete clefts of the lip and palate. However, the precise cause has not been confirmed. It has been suggested that these differences could be as a result of the morphogenetic pattern, adaptive changes, lip and/or palate management, or a combination of these factors (Chierici et al., 1973; Bishara et al., 1976, 1985; and Trotman et al., 1993).

2.1 Craniofacial Morphology In Cleft Lip And Palate Children

The facial form in adult individuals with repaired unilateral cleft lip and palate (UCLP) compared with the facial form in non-cleft subjects is characterized by a general retrusion of the profile relative to the cranial base involving the nasal bone, maxilla and mandible. The most striking features of the UCLP patients reside in the maxilla. The maxilla is retrognathic with a decreased anteroposterior length (Dahl, 1970; Šmahel and Brejcha, 1983; Bishara and deArrendondo, 1985; Šmahel and Müllerová, 1986; Trotman et al., 1993; Öztürk and Cura, 1996) and retroclined incisors (Öztürk and Cura, 1996; Semb and Shaw, 1996). There is severe reduction in posterior but only slight reduction in anterior maxillary height resulting in a backward rotation of the palatal plane in relation to the cranial base (Semb, 1991; Öztürk and Cura, 1996). An increased vertical length of the anterior maxilla has also been reported (Normando et al., 1992).

The mandible has an increased gonial angle and a steeper mandibular plane, and there is an increase in lower facial height (Dahl, 1970; Šmahel and Brejcha, 1983; Paulin, 1991; Semb, 1991; da Silva et al., 1993; Öztürk and Cura, 1996).

Some investigators reported an increase in the cranial base angle (Dahl, 1970; Öztürk and Cura, 1996). However, others found no or minor difference (Ross, 1965; Šmahel and Brejcha, 1983; Semb, 1991; Trotman et al., 1993), and Harris (1993) found it to be smaller. Mølsted et al. (1993) found the spheno-occipital synchondrosis broader and the distance from the superior part of the synchondrosis to the sella point shorter in neonates with UCLP compared to neonates with cleft lip and alveolus.

Dahl (1970) concluded that the changes in mandibular position and shape exerted a marked influence on the vertical development of the face. He further stated that owing to the pronounced flattening of the cranial base laterally, the mandibular condyles had a higher position in the cleft patients. This diminished the posterior facial height and resulted in a greater backward inclination of the mandibular plane. The increase in anterior facial height was integrated as a secondary reaction to increased backward inclination of the mandible, aiming to maintain a normal relation between the dental arches. On the other hand, differences in cranial base angle and posterior face height with backward rotation of the mandible and increased anterior face height are attributed as compensatory changes, promoted by differences in mode of respiration leading to mouth breathing (Warren et al., 1969; Bishara et al., 1985; Heliövaara and Ranta, 1993; Šmahel et al., 1993).

Semb (1991) in a mixed longitudinal study of 257 cases of complete UCLP found almost no increase in the length of the maxilla between 5 and 18 years of age. The dimension increased by only 1.4mm for the UCLP sample while increasing by approximately 10mm in the non-cleft sample recorded in the templates of the Broadbent standards. There was a concomitant reduction in maxillary prominence at the dentoalveolar level. A marked reduction in mandibular prominence over time was also found. The excessive lower face angulation changed little over time in the UCLP sample.

Comparison of craniofacial features of unoperated clefts, particularly in adults, with repaired cleft patients, can provide some insight into the natural history of this group of conditions and the possible influence of surgical management on growth. Some of the reports on unoperated clefts (Dahl, 1970; Bishara, 1973) concluded that there are significant differences in the dentofacial relationships between treated and untreated persons with unilateral cleft lip and palate and normal persons. The effects of lip and/or palate surgery are therefore superimposed on existing differences in the dentofacial structures. However, others (Ortiz-Monasterio et al., 1959; Mestre et al., 1960; Ortiz-Monasterio et al., 1966, Bishara et al., 1976, 1985 and1986; Ehmann, 1989, Mars and Houston, 1990; Capelozza et al., 1993) believe that untreated persons with UCLP have the same growth potential as non-cleft persons and that the anomaly is limited to the immediate area of the cleft. Therefore, the differences seen between the UCLP and non-cleft patients are entirely due to the surgical management.

Unoperated adults with UCLP showed no significant difference between the cranial base length and angle, to that of non cleft controls, though there is a trend towards a reduced length in the cleft group (Mars and Houston, 1990; Capelozza et al., 1993). Most studies on unrepaired UCLP patients found that these patients had cephalometrically normal maxillary growth (Ortiz-Monasterio et al., 1959; Mestre et al., 1960; Ortiz-Monasterio et al., 1966, Bishara et al., 1976, 1985 and1986; Ehmann, 1989, Mars and Houston, 1990; Capelozza et al., 1993). Ortiz-Monasterio et al. (1966) and Bishara et al. (1976) reported that the maxilla was similar to the normal group in the sagittal position whereas Mars and Houston (1990) reported insignificant protrusion and Capelozza (1993) found significant protrusion only for males. However, a few studies described findings of a relatively retruded maxilla (Dahl, 1970; Bishara, 1973; Isiekwe and Sowemimo, 1984; Yoshida et al., 1992).

Some studies found the mandible was steeper and/or retruded (Ortiz- Monasterio et al, 1966, Bishara et al., 1976, 1985 and1986; Ehmann, 1989, Mars and Houston, 1990; Yoshida et al., 1992; Capelozza et al., 1993), while others reported no significant difference in the mandible when compared to normal populations (Mestre et al., 1960; Dahl, 1970; Sakuda et al., 1988).

Studies of monozygotic twins provide further evidence of inherent differences in the face of individuals with clefts. Monozygotic twins have almost identical genetic constitutions and they share similar parental environments. Hence, twins discordant for CL/P are valuable resources in the study of craniofacial growth and development. In particular, studies on the CL/P twins that consist of unoperated and operated subjects can provide valuable information, because the unoperated subject serves as a suitable control for the operated sibling. A number of clinical studies (Ross and Coupe, 1965; Cronin and Hunter, 1980; and Trotman et al., 1993), case reports (Crooks, 1974; Burke and Hughes, 1987; Moriyama et al., 1998), and review articles (Hunter, 1981) have been written concerning craniofacial morphology of cleft twins. These studies have suggested that the intra-pair differences between twins discordant for CL/P varied according to each cleft type.

Subjects with UCLP have been reported to show deficient maxillary development in anteroposterior size and position (Trotman et al., 1993; Moriyama et al., 1998) and lingual tipping of the upper and lower incisors (Ross and Coupe, 1965; Moriyama et al., 1998). Regarding the mandibular dysmorphology of UCLP, a retropositioned mandible (Ross and Coupe, 1965; Cronin and Hunter, 1980; Moriyama et al., 1998) and a clockwise mandibular rotation (Ross and Coupe, 1965; Moriyama et al., 1998) have been reported. However, no significant intra-pair differences in the mandible, using twin samples were, reported by Crook (1974) and Trotman et al. (1993).

Trotman et al. (1993) reported that UCLP subjects exhibit a maxillary arch contraction in comparison to the unaffected sibling. Moriyama et al. (1998) also reported that the dental arch of the child with UCLP was deficient in anteroposterior and transverse dimension. In addition, the vertical height of the alveolar crest of the child with UCLP was relatively deficient. The palatal surface area and palatal volume of the UCLP child were only 55.0% and 35% of those of the non-cleft twin.

2.2 Surgical Management and the Craniofacial Morphology of UCLP Children

The impact of surgery on maxillary growth remains a central issue in the controversy surrounding the surgical management of the UCLP patient. Although attention was drawn to the dramatic effects of surgically induced growth impairment more than 50 years ago, how much contemporary surgery interferes with the growth and whether lip or palatal surgery is more harmful remains a matter of dispute. In addition, controversy remains about the importance of surgical technique, timing of surgery and surgical skill.

Controversy exists whether lip or palatal surgery is the primary cause of maxillary growth restraint (Graber, 1954; Ross, 1970; Mars and Houston, 1990; Capelozza et al., 1996). Ross (1970) introduced the concept of maxillary ankylosis to describe the situation whereby as a result of surgery a continuum of scar tissue joins the maxilla, the palatine bone, and the pterygoid plates of the sphenoid thus inhibiting separation of these bones and ultimately forward and downward maxillary movement. Ross (1987d) concluded after evaluating the influence of different factors, such as timing of operation and surgical procedures that cleft lip repair has an insignificant impact on facial growth. Surgical management of the alveolus is mainly responsible for the overriding effect on the vertical dimensions, and that the surgical closure of the hard palate has an overriding effect on the anteroposterior dimensions and an inhibiting role in craniofacial growth. On the other hand, Bardach and Eisbach (1977) stated that primary lip repair always resulted in a certain degree of labial tension that is transferred as pressure to the underlying maxilla, which may significantly interfere with normal maxillary growth. Bardach (1990), in a retrospective review of his previous clinical and experimental research, restated his original hypothesis that cleft lip repair, and not palate repair, should be considered to be the major cause of the maxillofacial deformities observed in the population with clefts. Mars and Houston (1990) and Capelozza et al. (1996) also showed that lip surgery alone had a major influence on maxillary development, due to the increased lip pressure. However, the inherent weakness in their study design was the absence of subjects who have had palatal surgery only.

Surgical effects seem mainly limited to the maxillary base and arch. Šmahel and Müllerová (1986) found that shortening of the maxilla was not present in UCLP children prior to palate surgery. These results, in addition to those of unoperated cleft individuals which indicated a potential for normal maxillary growth (Mestre, 1960; Bishara et al, 1976), gives evidence for an iatrogenic aetiology for maxillary deficiency, most probably due to the tension exerted by scar tissue postoperatively. Reduction of upper face height and the posterior position of the maxilla, however, were observed in both the unoperated UCLP children (Bishara and deArrendondo, 1985) and in the UCLP children prior to palatoplasty (Šmahel and Müllerová, 1986). These deviations are thus unrelated to surgery and most probably represent prenatal deviations due to an impairment in the interaction between the maxilla and the growth regulating nasal septum (Latham, 1969) or due to deficient growth within the circummaxillary systems of sutures, which shifts the maxilla in an anterior direction (Šmahel et al, 1993).

2.2.1 Primary Surgery

The impact of early reconstruction of cleft lip and/or palate on morphologic and functional development of the involved structures has been a matter of controversy. Ross (1987d) concluded that variations encountered in timing and technique of cleft lip repair has an insignificant impact on facial growth or dentoalveolar development. However, cases treated at 4 months of age or later have a more favourable development. The choice of technique therefore seems to be mostly a matter of personal preference for what the operator believes will give the best aesthetic and functional results.

An area of disagreement is whether surgery to the alveolus at the time of lip repair will cause growth impairment. One theory is that interference with the vomeropremaxillary suture may cause growth disturbance (Friede, 1978).

There is extensive controversy with respect to closure of the palate and its influence on maxillary growth. Much of this confusion focuses on two areas of contention viz. the timing of closure and the surgical technique. Early surgical closure of the palate is advocated in order to facilitate normal speech development (Blijdorp and Muller, 1984), whereas delayed closure is claimed to minimize adverse growth (Robertson and Jolleys, 1974; Hotz et al., 1978, Witzel et al., 1984). Later closure of the palate is based on the hypothesis that the major disturbance in craniofacial growth of patients with complete UCLP is attributable to palatal surgery. Neither policy is supported by good evidence, although delayed palatal closure beyond 12 years has been demonstrated to significantly impair normal speech even though maxillary growth has been better (Schweckendiek, 1978; Bardach et al., 1984). Blijdorp and Egyedi (1984) found no difference between the results when the hard palate was repaired at 3 years and 6 years of age. Ross (1987e) showed that the best results were those that completed surgery by 11 months whereas those who had late repairs after 20 months, including delayed hard palate repair at 4 to 9 years, following soft palate repair at infancy showed the poorest results.

One of the distinctions between palatal surgical procedures is in the staging of the hard and soft palate. Gillies and Fry (1921) first discussed the possibility of a two-stage procedure as a response to the poor facial growth that was seen in children with repaired clefts. They hoped by repairing the soft palate early, the benefit to speech would be appreciable, while later repair of the hard palate would be beneficial for maxillary growth.

The second major area of difference in palate repair is with respect to the Von Langenbeck and pushback procedures. The pushback procedure elevates and mobilizes mucoperiosteal flaps, which are translated posteriorly to achieve maximum length of the soft palate to hopefully improve the velopharyngeal valving. This procedure inevitably leaves more scar tissue in the anterior region, which would be harmful to maxillary growth. The Von Langenbeck procedure requires less mobilization and displacement of the mucoperiosteal flaps, and should result in less residual scar tissue, particularly in the anterior palate.

2.2.2 Alveolar Bone Grafting

Although, bone grafting to repair the cleft alveolar process has long been part of the accepted treatment regimen for the cleft palate patient, there is disagreement as to the optimal time for bone grafting. Primary bone grafting in infants, often defined as that which takes place before eruption of the primary dentition or before 1 year of age (Koberg, 1973), was introduced in the 1950s. The rationale for primary grafting was that it prevented maxillary arch collapse, provided stabilization of the maxilla in the infants with bilateral clefts, allowed normal development of the craniofacial complex and also promoted eruption of the deciduous dentition into the grafted area. Additional benefits cited by Nylen et al. (1974) were the support it provided for the alar base, and because palatal closure was facilitated, it provided an opportunity for improved speech.

The adverse effects of primary grafting on maxillary growth have been demonstrated in numerous studies (Lynch, 1970; Rehrman et al., 1970; and Friede and Johanson, 1974; Robertson and Jolleys, 1983; Ross, 1987c; Brattström et al., 1991; Shaw et al., 1992a). These studies indicated that early bone grafting compromised growth of the midface together with a higher incidence of malocclusion, and poor long-term graft stability. Koberg (1973) in a review of the history of bone grafting reports available in the literature concluded that severe maxillary deformity predictably resulted from primary bone grafting. However, there remain a few advocates of primary bone grafting because of specific surgical individual variability (Rosenstein et al., 1982). Rosentein et al. (1982) stressed the importance of non-interference with the growth of the vomeropremaxillary suture with there surgical technique. They reported similar maxillary growth in their sample of thirteen UCLP children who underwent primary osteoplasty compared to a sample of thirteen UCLP wherein no primary bone grafting was done.

Perioplasty was introduced as an alternative to primary bone grafting. The advantage of this 'boneless bone graft' was that continuity of the maxillary segments was established by local periosteal flaps, with the intention of promoting bone formation in the cleft site (Skoog, 1967 – cited in Vig et al., 1996). After completion of this procedure in infants, bone formation was reported in the cleft with no apparent adverse effects on facial growth (Hellquist and Ponten, 1979). Rintala and Ranta (1989) emphasized that the introduction of primary perioplasty did not significantly improve maxillary growth and did not prevent lateral collapse of the maxilla. Although Šmahel et al. (1998) reported a reduced retrusion of the upper jaw following primary perioplasty they concluded that this surgical method had no substantial advantages that cannot be achieved by another procedure.

Boyne and Sands (1972) described a secondary or delayed alveolar bone grafting procedure as bone grafting performed after primary lip repair. Depending on the timing, secondary bone graft can be divided into early secondary (5 and 6 years), intermediate or secondary (9 and 11 years or before permanent canine eruption) and late secondary or delayed (after eruption of the permanent canine). Boyne however, classifies early at 2 to 5 years, secondary as 6 to 15 and late in adolescence to adulthood. The timing of bone grafting should be related to root development of the canine, which should be ¼ to ⅔ complete at the time of bone grafting. At this stage in root development, there is apparently an accelerated eruption (Troxell et al., 1982).

Advocates for early secondary grafting, claim that the bony support for the future eruption of the lateral permanent incisor is an important consideration in the periodontal health of this tooth adjacent to the cleft site. However, the same factors affecting growth and development of the midface in primary bone grafting are also considerations during early secondary bone grafting.

Proponents of secondary grafting claim that there is little disruption to facial growth because a larger percentage of the adult size has been achieved before grafting. In addition, the canines are expected to migrate and erupt through the grafted area resulting in improved development of the dentition, improved bony environment to facilitate orthodontic and prosthodontic treatment, and improved stability and health of the periodontium. Delayed grafting has been reported as a possible method to achieve a firm anatomic base to aid orthodontic or prosthodontic management while avoiding interference with facial growth (Hogeman et al., 1972). However, Boyne and Sands (1972) oppose delayed grafting because postponement of the graft results in lack of sufficient bone support for the teeth adjacent to the cleft.

Ross (1987c) in a multicenter comparison study noted that patients with bone grafts performed between ages of 4 and 10 years showed marked deficiency in anterior upper facial height at age 15 years compared to ungrafted patients. In general, bone grafted between 9 and 12 years produced no difference from the ungrafted, although the late grafted sample from Oslo showed significantly shorter anterior maxillary height than the Toronto Lindsay sample with unrepaired alveoli. Semb (1988) also found no statistically significant difference in either anteroposterior or vertical maxillary growth when comparing 28 children with UCLP from Oslo who had alveolar bone grafts between the ages of 8 and 12 years to 30 control children with UCLP who had no alveolar bone grafts. Daskalogiannakis and Ross (1997) found similar results in the UCLP children from Toronto. They reported that mixed dentition bone grafting does not affect subsequent vertical and A-P development of the maxilla in complete unilateral cleft lip and palate patients during the first several postoperative years (ave. 3years).

Brattström et al. (1991) compared cephalometrically 85 patients with unilateral cleft lip and palate who were treated in three different centres (Stockholm, Oslo, and Toronto) according to four different regimens. They found that regimens that included primary bone grafting to the alveolus resulted in inhibited anterior maxillary growth. Regimens that included secondary bone grafting resulted in better maxillary development but were not as good as regimens that omitted bone-grafting altogether.

Bergland et al. (1986) reported retrospective data with strict protocols on a series of more than 350 patients, and they concluded that elimination of the residual alveolar cleft with the use of cancellous bone grafts before eruption of the permanent canine tooth promoted consolidation of the supporting bone in the cleft site and eliminated the need for bridgework in young adults. In a smaller series, it was also found that placing the graft before eruption of the canine tooth provided periodontal benefits (Turvey et al., 1984). Sindet-Pedersen and Ennemark (1985) reported on the periodontal status of three groups of patients who had received bone grafts. They found no periodontal defects in the youngest group (5-14yrs). Periodontal defects were present in the older group (16-38yrs) as well as an increased incidence of fistulas.

2.3 Role of Intercentre Studies in Cleft Palate Research

Certain aspects of CLP clinical research have made the evaluation of treatment outcome particularly difficult. These include the multidimensionality of outcome, length of follow up, reproducibility and validity of outcome measures, diversity of management and sample size (Roberts et al., 1991). With an incidence around two births per thousand, the considerable variety of cleft subtypes, and the common decentralized nature of care, few centres are able to accrue adequate samples for hypothesis testing within a period when surgical and other key variables can be standardized (Shaw et al., 1992b). Inevitably this has produced literature that is flawed by small samples or dubious groupings of patients with respect to presurgical classification and management. In even the busiest CLP treatment centres the generation of adequate samples within specific cleft subtypes treated by contrasting treatment modalities is extremely difficult. Consequently a multicentre/intercentre approach offers distinct advantages.

Intercentre studies offer particular advantages in CLP clinical research because they allow direct comparison of outcome of primary surgery together with other major components of the treatment program at respective centres. The intercentre studies cannot eliminate susceptibility and proficiency bias (the patients are drawn from different populations and the surgeons are inevitably different). Thus, they are not appropriate for studying individual aspects of surgical or other protocols. However, with appropriate planning they can limit detection, exclusion, analysis and report bias, permitting a reliable indication of the overall level of outcome achieved by the entire service, including protocols and proficiency. Major contrast in the type of treatment and delivery of care as a whole may be examined. However, it is difficult if not impossible, to establish the key beneficial or harmful features of a specific treatment as a general scientific conclusion, due to the invariably complex and arbitrary mix of surgical technique, timing and sequence, ancillary procedures, and surgical personnel. For example, if two centres differ in the use of presurgical orthopaedics and types of primary lip and palate surgery, there is no way to determine which of these procedures might be responsible for any difference in outcome between centres, nor would a null result allow the conclusion that individual aspects of the treatment program are equivalent. The method is therefore better suited to comparative clinical audit than definitive clinical research. Nevertheless the existence of significant disparities in outcome of the overall treatment process provides a basis for speculating as to the possible cause. This can be a powerful stimulus for an overhaul of services that have proved deficient (Sandy et al., 1998). Intercentre studies should therefore be highly motivating toward the generation of specific hypothesis for more detailed prospective trials, which may in the long term improve results even in the better centres (Roberts et al., 1991). Intercentre studies can also provide an opportunity for comparing the costs, complexity, and burden of care; they may promote openness, encourage cooperation (rather than competition), and promote collaborative work on outcome methodology (Semb and Shaw, 1998)

A review of the Cleft Palate Journal, since its inception until the end of 1988, revealed only six such studies, and these were mainly confined to a single aspect of treatment outcome (Roberts et al., 1991). These represented 5 percent of 117 identified reports on some aspects of treatment outcome. Facial growth and dental occlusion were most frequently studied (Bishara, 1974; Cronin and Hunter, 1980; Dahl et al., 1981; Ross, 1987a,b,c,d,e,f,g; Mars et al., 1987) and one report dealt with speech pathology (Van demark, 1974). Semb and Shaw (1998) carried out a search of the literature which included, searching the electronic data bases Medline and Embase from 1966-1997, hand searching the Cleft Palate and Craniofacial Journal from 1964-1997; searching the Cochrane Trials Register, and following up relevant citations in papers read, in an attempt to determine the facial growth after different methods of surgical intervention in patients with UCLP. A total of 5474 titles were identified which contained 189 relevant reports, of which only 20% were eligible after a preliminary analysis. This was due to considerable variation in the reported detail and methodology. From their search, three papers were reported as having the highest level of maxillary prominence (Ross, 1987a; Ross, 1995; Trotman et al., 1996).

Ross (1987a,b,c,d,e,f,g) performed a multicentre study on the affects of various treatments on the facial growth of children with unilateral cleft lip and palate, using lateral cephalographs. His study found that different approaches affected the position and the size of the maxilla to different degrees. Differences observed between the more common techniques were slight. Presurgical orthopaedics in the neonatal period had no apparent long-term beneficial or detrimental effect on the facial growth in height and depth. The effects measured were negligible in his study, although there was the possibility of some negative effects with extraoral strapping technique. Treatment regimes leaving the alveolus untouched and in which the hard palate was not operated on showed the best development of the maxilla. The type of palate closure, however, was not important for facial growth. On the other hand, there was a strong suggestion that the skill of the surgeon rather than the technique employed influenced the final outcome with regard to facial growth.

An inter centre study of four Scandinavian cleft centres also showed that there are different treatment outcomes, particular occlusal differences, in UCLP children treated at these centres (Friede et al., 1991). Occlusion seemed to be least affected in the two stage palatal group. These results differed significantly from the outcome of the two cleft centres, which used push back closure.

Brattström et al. (1992a,b,c) evaluated the treatment outcomes of UCLP children treated at three centres – Stockholm, Oslo and Toronto. The Toronto group showed the most favourable maxillary development followed by the Oslo group. The treatment differences between the Toronto and Oslo group were firstly, the use of the two flap push back method for palatal closure and the absence of bone grafting in the Toronto group compared with a von Langenbeck closure including a vomer flap procedure in the Oslo group. Despite the more traumatic procedure of palatal closure, the absence of bone grafting in the Toronto group seemed to offer better maxillary development.

The European Cleft Lip and Palate Team conducted a six-centre international study of treatment outcomes of children with repaired unilateral cleft lip and palate (Asher-McDade et al., 1992; Mars et al., 1992; Mølsted et al., 1992; Shaw et al., 1992a, b). Statistical comparison of the six groups indicated that midfacial development was impaired at some centres more than at others, especially when soft tissue outline was considered (Mølsted et al., 1992). One centre (centre D) produced rather poor treatment outcome when compared to the other centres. This was in part attributed to the use of extraoral strapping. The characteristic features in children at this centre were decreased distance between sella and pterygomaxillare, retroclination of the upper incisors, flattening of the nose, short upper lip and a decrease in sagittal soft tissue relations. Furthermore the treatment outcome at centres where a simple management approach was used produced equally compared to the centre using a more complex and expensive procedure, which included presurgical orthopaedics and primary bone grafting. A five point ranking of the Goslon yardstick also showed that the children at some centres had a considerably higher risk of midfacial retrusion that would call for surgical maxillary advancement (Mars et al., 1992). Shaw et al. (1992b) emphasized the size of the surgeon's caseload as an important explanatory factor in the difference in treatment outcomes. Centres B and E with a centralized organizational structure and relatively high caseloads per surgeon performed better than centres C and D, which had a large number of low volume operators. The single surgeon in centre B treated 54 UCLP patients over a 3-year period, whereas 83% of the twelve surgeons in centre D treated three or fewer UCLP patients.

Trotman et al. (1996) compared the craniofacial morphology of UCLP children at two different American centres (Chicago and Lancaster). The results of their investigation clearly indicated that patients who underwent primary bone grafting (Chicago group) ultimately had maxillae that were significantly less protrusive than the non-grafted sample. However, no difference in the maxillo-mandibular relationships was observed, largely because of the alterations in the mandibular morphology noted in the primary alveolar bone group.

Leonard et al. (1998) recently reported on the quality of treatment outcome of a sample of Northern Irish children with UCLP children compared to those reported for the six-centre study. Their study found no significant difference for the cephalometric variables measured compared to the Eurocleft study. On average, the Northern Irish UCLP children showed significantly better soft tissue facial contour and sagittal lip profile compared to the Eurocleft's centre D. Analysis of the Goslon Yardstick revealed that the quality of the dental arch relationships of the Northern Irish UCLP children fell approximately midway between the best and the worst Eurocleft centres.

CHAPTER 3

3.1 AIM

The purpose of this study was to evaluate the treatment outcomes of children with unilateral cleft lip and palate (UCLP) treated at the Red Cross Children Hospital (RCCH), with respect to craniofacial and dental morphology.

3.2 OBJECTIVES

1. Evaluate the craniofacial and soft tissue profile of UCLP children.
2. Assess the dental arch relationship in UCLP children according to the Goslon Yardstick – (Mars et al., 1987).
3. Compare these cephalometric and dental findings with those of the Six-Centre International Study – (Mølsted et al., 1992; Mars et al., 1992).

3.3 MOTIVATION FOR STUDY

Patients with UCLP in the Western Cape receive treatment at either one of two centres (Red Cross Children's Hospital or Tygerberg Hospital) or privately. No studies on craniofacial and dental morphology and treatment outcomes of UCLP at these centres in the Western Cape have been done. Neither has the treatment protocol followed by these centres been defined. This study will form part of a larger study assessing various aspects of treatment outcomes of the UCLP children treated at RCCH.

CHAPTER FOUR

4. MATERIAL AND METHOD

4.1 Sample and Material

A sample of 20 children with UCLP was collected from the records of the RCCH according to the following criteria:

- All patients had a complete unilateral cleft of the lip, alveolar process and palate. The diagnosis being confirmed from preoperative clinical notes or neonatal photographs.
- All consecutive cases were included.
- All subjects would have been between the ages 8 to 11 years old at the time of record collection (cephalometric films and dental cast). The sample thus, included children born between the period of October 1987 to January 1992.
- All primary surgical procedures had been performed at the RCCH, Department of Plastic and Reconstructive Surgery.
- No comprehensive fixed orthodontic treatment had been done.
- Patients with a history of additional craniofacial anomalies were excluded.

The sample consisted of 11 females and 9 males. The ages ranged from 8.33 years to 11.92 years with a mean of 10.13 ± 1.20 years. All the patients had a cleft of the lip and alveolus on the left side. None showed the presence of a Simonart's band.

4.2 Clinical Management

All primary surgical procedures were performed by a senior plastic surgeon assisted by a clinical registrar in the Department of Plastic and Reconstructive Surgery. Except for one case, all primary procedures were performed by one senior plastic surgeon. A one stage primary repair of the lip and palate was performed on 19 patients between 3 and 8 months of age (mean age 5.35 ± 2.23 months). The primary surgical management consisted of a modified Davies Z plasty lip repair and an inferior based vomer flap repair of the hard palate together with a von Langenbeck technique for closure of the soft palate. In four patients the lip was repaired using the Millard procedure and in two patients the palate was repaired with a Witmaiers and Wiedermeyer and Cronin procedures respectively. In one patient the lip was repaired at 2 month of age with a modified Davies Z plasty, which was followed with closure of the palate at 8 months of age. Closure of the palate was achieved with a vomer flap plus a Furlow Z plasty closure of the soft palate. Twelve patients had alveolar bone grafts, which were performed between the ages of 8 and 12 years (mean 9.41 ± 1.45 years).

4.3 Cephalometric Analysis

The cephalometric films were all obtained under standardized conditions using the Siemens Orthophos CD machine. The focus object distance was 150cm and the object film distance 13 cm. The following settings were used to obtain better contrast for soft tissue profile and visualisation of *A* point: kV = 67, 1.5 msec and 15mAmps. The cephalographs were taken with the patient in the natural head position and the teeth in occlusion.

The cephalometric skeletal and soft tissue points and reference lines, used in this study were according to those described by Mølsted et al. (1992) - *Appendix A*. The reference points were identified by the principal examiner and checked by a second examiner. The reference points were marked directly on the radiograph with a Pilot extra fine ink marker. Where bilateral structures produce a double contour on the cephalometric radiograph, measurements were made to a point midway between the contours. Based on these cephalometric points 8 skeletal and 11 soft tissue variables were analysed.

The radiographs were digitised using a Microtek Scanmaker 4 scanner and the Adobe Photoshop 5.5 software package. The images were acquired in the transmissive mode at 150dpi (dots per inch) and saved in a JPEG (Joint Photographic Experts Group) file format. The marked reference points were then digitised and the measurements calculated using the Autocad 2000 software package as follows:

- Correction for the x-ray magnification was first carried out. The scale was set according to the ruler on the cephalogram so that a 1:1 scale was obtained.
- Digitisation of the marked reference points. To ensure the accuracy of the method, the images were first magnified by zooming in on the marked reference point. The marked reference point was then circled and the centre

of the circle was used as the reference point to further ensure the accuracy and resolution of the method.

- The reference points were joined to obtain the cephalometric reference lines.
- The linear and angular measurements were calculated in millimetres and degrees to the nearest second decimal point.

In order to determine the reliability of the method, the cephalometric tracings were repeated for 5 radiographs, selected randomly, after an interval of 4 week.

4.4 Dental Analysis

The dental relationship of the UCLP patients were assessed according to the Goslon Yardstick described by Mars et al. (1987). The Goslon Yardstick assesses the dental arch relationship in terms of anteroposterior, transverse and vertical discrepancies in persons with cleft lip and palate. The assessment is based on a five-grade categorical scale that compares the dental arch relationships of UCLP patients with those of a master set of study models. A very good dental arch relationship is scored as group 1 and a very poor relationship as group 5. In general, groups 1 and 2 can be considered as excellent and good dental arch relationships and group 3 as satisfactory. Group 4 and 5 are considered as poor or very poor dental arch relationships, which most likely require osteotomy of the maxilla to restore appearance and function.

Each of the dental cast was assessed and scored according to the assessment described by Mars et al (1987) - *Appendix B*. To analyse intra- and inter-observer reliability, the models were analysed on two separate occasions by the principal examiners at 4 weeks apart and by a second examiner.

4.5 Intercentre Study Analysis

The mean cephalometric values and the Goslon dental scores recorded for the RCCH patients were compared to that recorded for the Six-Centre International Study (Mars et al., 1992; Molsted et al., 1992).

4.6 Statistical Analysis

The software programs Microsoft Excel 2000 and Epi Info 6 were used for data management and statistical analysis. Mean and standard deviation values were calculated for the descriptive variables. The method error associated with the cephalometric analysis was calculated using the Dahlberg formula (Dahlberg, 1940) as follows:

$$\text{Method Error} = ME = \sqrt{\sum d^2 / 2n}$$

where d is the difference between the 2 registrations of a pair and n is the number of repeat registrations. Systematic error was assessed using a t-test as recommended by Houston (1983).

The cephalometric mean values for the RCCH were compared to those in each centre in the six-centre international study using the 't' test for independent samples at a 95% level of confidence. A 95% confidence interval was also calculated to determine the precision of the sample estimate for each variable for each centre.

Reliability between and within the observer for the dental analysis was assessed using the Kappa coefficient test. As both assessors scored all the models, the scores were pooled together to generate a mean score for each model. The mean score was compared to that of the six centres using a t-test for independent samples at a 95% level of confidence. A 95% confidence interval was also calculated to determine the precision of the sample estimate. The cumulative Goslon scores were also compared to that of the six-centre international study.

4.6 ETHICAL AND LEGAL CONSIDERATIONS

This research was registered with the University of the Western Cape Senate Research Committee (Project registration – 00/4/1). This committee also granted ethical clearance for this research. Consent was obtained from the Senior Medical Superintendent at the RCCH for use of the patient's clinical records and material (*Appendix – D*).

CHAPTER FIVE

5. RESULTS

5.1 Method error and reliability

The analysis of the 5 repeat cephalometric tracings showed method errors within acceptable limits of less than 0.5 degrees and 0.5mm for both the skeletal and soft tissue measurements as summarised in Tables 1 and 2. The results of the paired t-test showed no significant systematic errors for either the cephalometric skeletal or soft tissue variables.

Variable	Method Error	Systematic Error (P)
s-n-ss	0.10	0.87
pm-ss	0.18	0.21
s-pm	0.05	0.88
n-sp	0.12	0.77
NSL-NL	0.10	0.96
s-n-pg	0.20	0.73
NSL-ML	0.13	0.80
l1s-NL	0.16	0.54

Table 1. Method and systematic error for cephalometric skeletal variables

Variable	Method Error	Systematic Error (P)
unt-ns-sss	0.17	0.84
ns-unt/NSL	0.23	0.37
ns-prn-sn	0.29	0.79
sn-stu	0.12	0.48
nst-sn-ls	0.17	0.27
sss-ss	0.04	0.26
li-id	0.08	0.41
li-sms-pgs	0.36	0.57
sss-sns-sm	0.04	0.56
sss-ns-pgs	0.09	0.70
gs-prn-pgs	0.31	0.58

Table 2. Method and systematic error for cephalometric soft tissue variables

The dental scores obtained by the same examiner on two separate occasions (referred to as observation 1 and 2) compared with each other and with the score obtained by an independent examiner (referred to as observation3), using the Kappa coefficient test, are summarised in Table 3.

Comparison	Kappa Coefficient
Observation 1 and 2	0.64
Observation 1 and 3	0.71
Observation 2 and 3	0.77

Table 3. Inter and intra observer reliability for dental analysis

The Kappa coefficients show significant agreement between the two observations for the examiner 1 and between the independent examiner and observations 1 and 2.

These analyses clearly establish reliability and reproducibility of the cephalometric and dental analyses and the data obtained.

5.2 Sample Analysis

The results of the chi-square test revealed no significant difference between the RCCH group and the children from the six-centre study for gender distribution (Table 4). Although no statistically significant differences were found, centres A. B. C. D and E had a larger percentage of males in relation to females in their samples.

Centre	Males n (%)	Females n (%)	Total	P- value
RCCH	9 (45)	11 (55)	20	-
A	14 (61)	9 (39)	23	0.298
B	17 (65)	9 (35)	26	0.166
C	16 (70)	7 (30)	23	0.103
D	16 (62)	10 (38)	26	0.264
E	20 (67)	10 (33)	30	0.124
F	10 (43)	13 (57)	23	0.920

Table 4. The gender distribution of the RCCH compared to the Six Centre International study ($P < 0.05$ indicates significant difference between RCCH and individual centre).

The mean age and age range at which orthodontic records were taken for the RCCH children were similar to those in the European centres Table 5.

Centre	Mean Age (years)	Age Range (years)
RCCH	10.1	8-11
A	9.2	8-10
B	9.6	8-10
C	9.5	8-10
D	9.5	8-10
E	9.7	8-10
F	9.3	8-10

Table 5. Mean age and age range of the RCCH sample and the Six Centre International study.

5.3 Cephalometric Analysis

Descriptive statistics, including mean, standard deviation, minimum, maximum and range for the cephalometric results are given in Table 6 and 7.

Variable	Mean	Standard Deviation	Minimum	Maximum	Range
s-n-ss	78.40	2.74	74.77	82.99	8.22
pm-ss	43.61	3.05	39.69	49.99	10.30
s-pm	35.97	5.09	24.32	43.58	19.26
n-sp	44.75	3.93	33.72	49.72	16.00
NSL-NL	12.98	4.40	3.99	21.11	17.12
s-n-pg	75.28	2.22	71.24	78.93	7.69
NSL-ML	39.00	4.70	30.14	48.29	18.15
l1s-NL	105.72	7.19	90.74	120.48	29.74

Table 6. Descriptive data for the cephalometric skeletal variables.

Variable	Mean	Standard Deviation	Minimum	Maximum	Range
unt-ns-sss	21.09	3.36	16.29	26.70	10.41
ns-unt/NSL	107.28	4.14	98.95	114.69	15.74
ns-prn-sn	106.13	5.39	94.61	115.91	21.30
sn-stu	17.86	1.98	14.04	21.18	7.14
nst-sn-ls	99.70	13.27	62.69	117.46	54.77
sss-ss	11.90	1.90	8.80	15.95	7.15
li-id	16.17	2.44	11.82	20.35	8.53
li-sms-pgs	136.64	15.50	110.11	166.64	56.53
sss-sns-sm	7.03	2.43	3.08	10.84	7.76
sss-ns-pgs	6.96	2.74	2.60	11.78	9.18
gs-prn-pgs	148.23	4.23	136.10	153.27	17.17

Table 7. Descriptive data for the cephalometric soft tissue variables.

The mean and standard deviations for cephalometric skeletal and soft tissue variables for the RCCH compared to those recorded for the six-centre international study are illustrated in Table 8 and 9 respectively. The 95% confidence interval for the mean values for the cephalometric skeletal and soft tissue variables for the RCCH and those of the six-centre international study showed good precision of the averages (Table 10 and 11). Table 12 and 13 shows the P-values computed after applying the t-test for independent samples to test the significant difference between the RCCH and the individual centres from the six-centre international study.

The results of the t-test showed no statistically significant difference between the RCCH group and the six centres for maxillary protrusion (s-n-ss) maxillary length (pm-ss) and the anterior and posterior maxillary height (n-sp and s-pm), except with centre D which had a significantly retruded maxilla compared to the RCCH group. Centre D also differed significantly with the RCCH group with respect to the anterior facial height (n-sp). A significant difference was found with regard to the maxillary inclination relative to the S-N line (NSL-NL) between the RCCH and centres A, B, C, E and F.

There was no significant difference in mandibular prognathism (s-n-pg) and mandibular inclination (NSL-ML) between the RCCH and the other centres, except with centre B which showed a reduced mandibular inclination compared to the RCCH.

A significant difference was found for the maxillary incisor inclination between the RCCH and the other centres except for centre E. The incisors were proclined in the RCCH group compared to Centres A, B, C, D and F.

Comparison of the cephalometric soft tissue variables using the t-test showed that the relative prominence of the nose (unt-ns-sss) of the RCCH group was significantly decreased compared to the other centres. The patients in centres A and D had flatter noses (ns-unt/NSL), which differed significantly with the RCCH group. The angle between the lower border of the nose and the upper lip (ns-prn-sn) showed no difference between the RCCH and the six centres.

The thickness of the upper lip (sss-ss) differed significantly between centres A and B and the RCCH group. The lower lip (li-id) and the upper lip length (sn-stu) showed no statistically significant difference between the RCCH group and most of the other centres except for centre D and C respectively.

With regard to the angle between the contour of the lower lip and the contour of the chin (li-sms-pgs), also no statistical significant difference was found except with centre C.

The sagittal soft tissue variable sss-ns-sms was significantly increased compared to centres D and F. The sagittal soft tissue variable sss-ns-pgs differed significantly compared to centres B, C, D and F. These soft tissue variables were decreased in these centres.

The facial contour (gs-prn-pgs) differed significantly between the RCCH and centre D. The centre D having a flatter facial contour compared to the RCCH group.

Variable	RCCH		Centre A		Centre B		Centre C		Centre D		Centre E		Centre F	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
s-n-ss	78.40	2.74	77.36	4.11	77.45	4.34	77.30	4.47	75.93*	4.55	77.07	3.52	76.40	3.54
pm-ss	43.61	3.05	43.82	2.84	43.12	3.09	42.57	2.76	41.72	4.26	42.11	2.56	42.21	3.07
s-pm	35.97	5.09	36.93	2.65	37.16	2.98	37.63	2.84	35.42	3.59	37.96	2.82	38.25	2.93
n-sp	44.75	3.93	44.39	2.81	43.41	3.20	44.19	3.21	42.50*	2.70	43.81	2.65	42.78	3.09
NSL-NL	12.98	4.40	11.11	3.97	9.79*	3.60	10.10*	4.53	10.63*	3.96	9.67*	3.17	7.83*	4.19
s-n-pg	75.28	2.22	73.93	4.05	75.24	3.53	75.57	3.81	75.59	3.40	75.43	3.28	75.39	3.03
NSL-ML	39.00	4.70	39.00	4.28	36.12*	4.60	37.03	4.71	38.36	3.65	36.44	4.86	39.69	5.10
11s-NL	105.72	7.19	101.20	8.16	99.04*	10.29	95.17*	10.15	92.40*	9.77	101.50	9.09	98.26*	9.17

Table 8. Descriptive data of the cephalometric skeletal variables for the RCCH and the Six-Centre International study
* P < 0.05

Variable	RCCH		Centre A		Centre B		Centre C		Centre D		Centre E		Centre F	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
unt-ns-sss	21.09	3.36	24.36*	3.54	25.46*	2.40	23.77*	3.44	23.67*	2.69	24.23*	2.64	27.69*	3.29
ns-unt/NSL	107.28	4.14	104.35*	3.72	106.62	4.76	104.95	4.77	102.81*	5.29	105.69	3.20	106.43	4.18
ns-prn-sn	106.13	5.39	104.52	4.94	104.29	4.21	106.77	7.10	105.05	8.16	103.74	4.84	104.11	6.11
sn-stu	17.86	1.98	18.68	2.29	18.46	2.33	18.28	2.67	17.27	3.16	18.52	2.40	20.22*	3.28
nst-sn-ls	99.70	13.27	104.35	11.66	104.06	11.30	106.81	12.57	100.56	14.12	101.47	12.28	98.58	11.98
sss-ss	11.90	1.90	10.56*	1.27	10.78*	1.45	10.94	1.93	10.71	2.13	11.85	2.33	11.10	2.06
li-id	16.17	2.44	16.48	2.02	16.11	1.86	14.94	2.44	14.37*	2.27	15.30	2.92	16.40	2.53
li-sms-pgs	136.64	15.50	136.88	13.57	129.04	14.95	125.75	10.48	138.69	15.69	133.36	13.72	134.62	12.58
sss-sns-sms	7.03	2.43	5.85	3.48	6.05	2.53	5.45	2.90	2.57*	3.34	5.98	2.46	3.56*	3.58
sss-ns-pgs	6.96	2.74	5.18	3.21	4.73*	2.82	3.98*	3.33	1.65*	3.80	4.83*	3.04	2.25*	4.23
gs-prn-pgs	148.23	4.23	149.27	5.50	150.11	5.06	148.85	4.54	154.25*	6.85	149.58	4.36	150.65	5.33

Table 9. Descriptive data of the cephalometric soft tissue variables for the RCCH and the Six-Centre International study
* P < 0.05

Variable	RCCH		Centre A		Centre B		Centre C		Centre D		Centre E		Centre F	
s-n-ss	77.12	79.68	75.62	79.10	75.73	79.17	75.41	79.19	74.05	77.81	75.76	78.38	74.69	78.11
pm-ss	42.18	45.04	42.62	45.02	41.90	44.34	41.40	43.74	39.96	43.48	41.15	43.07	40.73	43.69
s-pm	33.59	38.35	35.81	38.04	35.98	38.34	36.43	38.83	33.94	36.90	36.61	39.01	36.84	39.66
n-sp	42.91	46.59	43.20	45.58	42.14	44.68	42.83	45.55	41.39	43.61	42.82	44.80	41.29	44.27
NSL-NL	10.92	15.04	9.43	12.79	8.37	11.21	8.19	12.01	8.99	12.26	8.48	10.85	5.81	9.85
s-n-pg	74.24	76.32	72.22	75.64	73.84	76.64	73.96	77.18	74.19	76.99	74.21	76.65	73.93	76.85
NSL-ML	36.80	41.20	37.19	40.81	34.30	37.93	35.04	39.02	36.85	39.86	34.63	38.25	37.23	42.15
11s-NL	102.35	109.08	97.75	104.64	94.97	103.11	90.88	99.46	88.36	96.43	98.10	104.89	93.84	102.67

Table 10. 95% confidence interval for the mean of the skeletal variables for the RCCH and the Six-Centre International study.

Variable	RCCH		Centre A		Centre B		Centre C		Centre D		Centre E		Centre F	
unt-ns-sss	19.52	22.66	22.87	25.85	24.51	26.41	22.32	25.22	22.56	24.78	23.24	25.22	26.10	29.28
ns-unt/NSL	105.34	109.21	102.77	105.92	104.73	108.50	102.93	106.96	100.62	104.99	104.49	106.88	104.41	108.44
ns-prn-sn	103.60	108.65	102.43	106.60	102.62	105.95	103.77	109.76	101.68	108.41	101.93	105.54	101.16	107.05
sn-stu	16.93	18.79	17.71	19.64	17.54	19.38	17.15	19.41	15.97	18.57	17.62	19.42	18.64	21.80
nst-sn-ls	93.48	105.91	99.43	109.27	99.59	108.53	101.50	112.11	94.73	106.38	96.88	106.05	92.81	104.35
sss-ss	11.01	12.79	10.02	11.10	10.21	11.35	10.13	11.75	9.83	11.59	10.98	12.72	10.11	12.09
li-id	15.03	17.31	15.63	17.33	15.37	16.85	13.91	15.97	13.43	15.31	14.21	16.39	15.18	17.62
li-sms-pgs	129.38	143.89	131.00	142.00	123.10	134.90	121.32	130.17	132.21	145.16	128.23	138.48	128.55	140.68
sss-sns-sms	5.89	8.17	4.38	7.32	5.05	7.05	4.23	6.67	1.19	3.95	5.06	6.90	1.83	5.29
sss-ns-pgs	5.68	8.24	3.82	6.54	3.61	5.85	2.57	5.39	0.08	3.22	3.69	5.97	0.21	4.29
gs-prn-pgs	146.25	150.20	146.94	151.59	148.10	152.11	146.90	150.70	151.42	157.07	147.95	151.20	148.00	153.20

Table 11. 95% confidence interval for the mean of the soft tissue variables for the RCCH and the Six-Centre International study.

Variable	Centre A	Centre B	Centre C	Centre D	Centre E	Centre F
s-n-ss	0.3396	0.3950	0.3428	0.0385	0.1607	0.0553
pm-ss	0.8145	0.5916	0.2421	0.1023	0.0662	0.1615
s-pm	0.4261	0.3197	0.1796	0.6732	0.0820	0.0971
n-sp	0.7254	0.2043	0.6054	0.0281	0.3166	0.0912
NSL-NL	0.1460	0.0090	0.0393	0.0665	0.0033	0.0006
s-n-pg	0.1901	0.9647	0.7655	0.7268	0.8589	0.8974
NSL-ML	1.0000	0.0411	0.1740	0.6096	0.0707	0.6627
11s-NL	0.0604	0.0167	0.0003	0.0000	0.0878	0.0074

Table 12. P- values for the mean and standard deviation of the skeletal variables for the RCCH compared to the Six-Centre International study ($P < 0.05$ reveals significant difference between RCCH and individual centre).

Variable	Centre A	Centre B	Centre C	Centre D	Centre E	Centre F
unt-ns-sss	0.0032	0.0000	0.0128	0.0065	0.0006	0.0000
ns-unt/NSL	0.0176	0.6222	0.0943	0.0035	0.1328	0.5275
ns-prn-sn	0.3076	0.1953	0.7422	0.6133	0.1087	0.2800
sn-stu	0.2157	0.3578	0.5636	0.4709	0.3132	0.0095
nst-sn-ls	0.2229	0.2310	0.0756	0.8358	0.6309	0.7840
sss-ss	0.0079	0.0265	0.1054	0.0575	0.9367	0.2149
li-id	0.6469	0.9241	0.1033	0.0141	0.2769	0.7742
li-sms-pgs	0.9566	0.0967	0.0084	0.6637	0.4356	0.6586
sss-sns-sms	0.2083	0.1885	0.0598	0.0000	0.1438	0.0010
sss-ns-pgs	0.0572	0.0094	0.0026	0.0000	0.0150	0.0002
gs-prn-pgs	0.4929	0.1844	0.6442	0.0013	0.2832	0.1238

Table 13. P- values for the mean and standard deviation of the soft tissue variables for the RCCH compared to the Six-Centre International study ($P < 0.05$ reveals significant difference between RCCH and individual centre).

5.4 Dental Analysis

The dental analysis according to the Goslon Yardstick for examiner 1 on the two separate observations and examiner 2 are given in Table 14.

Dental Model	Examiner 1 1st Observation	Examiner 1 2nd Observation	Examiner 2
1	1	1	1
2	3	4	3
3	3	3	3
4	1	2	2
5	5	5	5
6	2	2	2
7	2	2	2
8	1	2	1
9	1	1	1
10	4	4	4
11	1	1	1
12	2	2	1
13	2	2	2
14	2	2	2
15	2	2	2
16	3	2	2
17	2	2	2
18	1	2	2
19	2	2	2
20	5	5	5

Table 14. Results of the Goslon analysis

The distribution of Goslon Yardstick scores for the RCCH group are given in Figure 1.

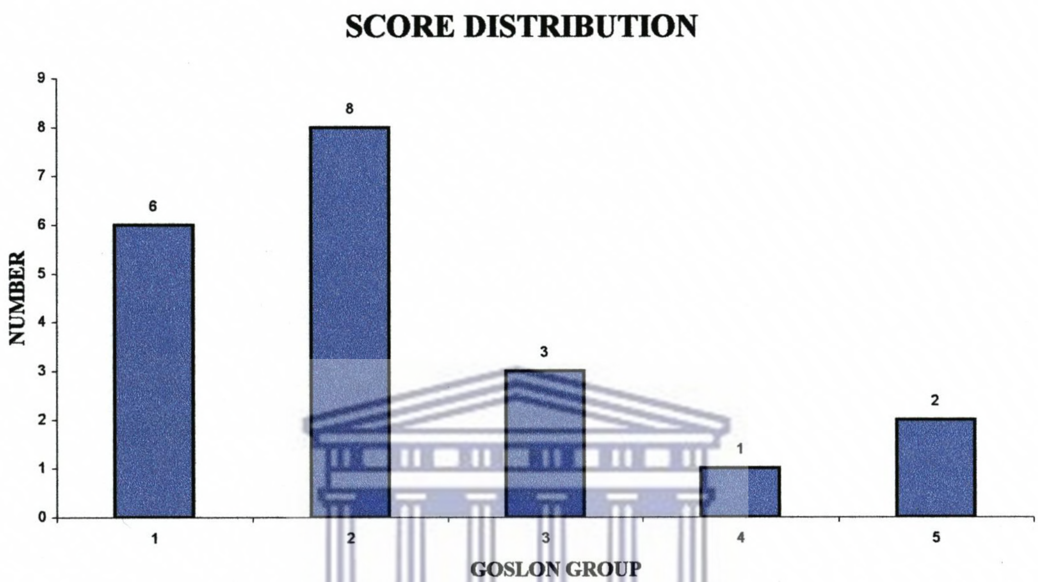


Fig. 1 The Goslon Yardstick score distribution.

The descriptive data for the pooled data are as follows:

mean = 2.30

std. dev. = 1.20

The frequency distribution for the Goslon Yardstick score for the RCCH group compared the six centres in the European multicentre study are illustrated in Figure 2.

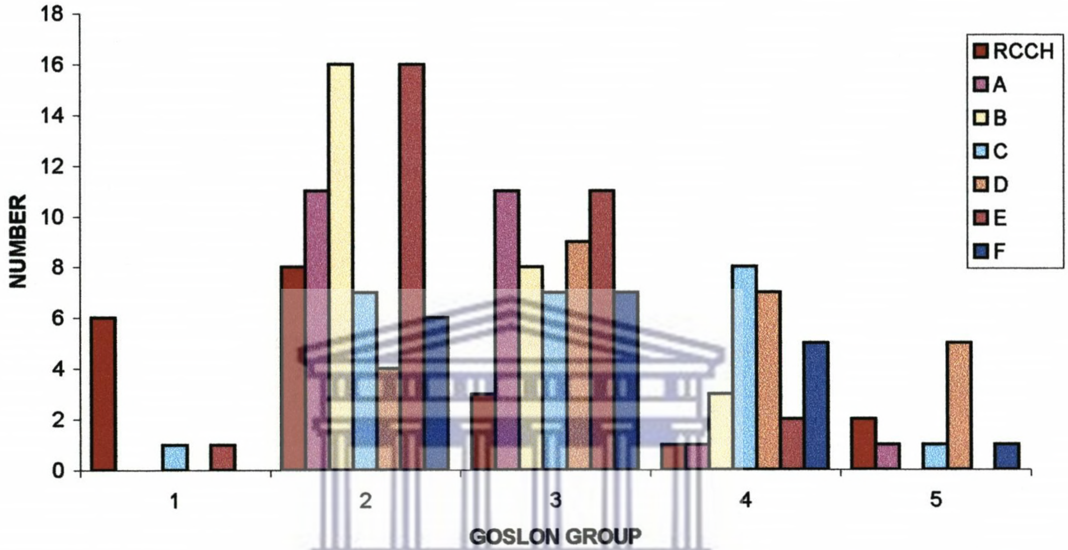


Figure 2. The Goslon Yardstick score distribution for the RCCH and the Six-Centre International study.

The cumulative Goslon Yardstick scores for the RCCH group compared the six centres in the European multicenter study are illustrated in Figure3.

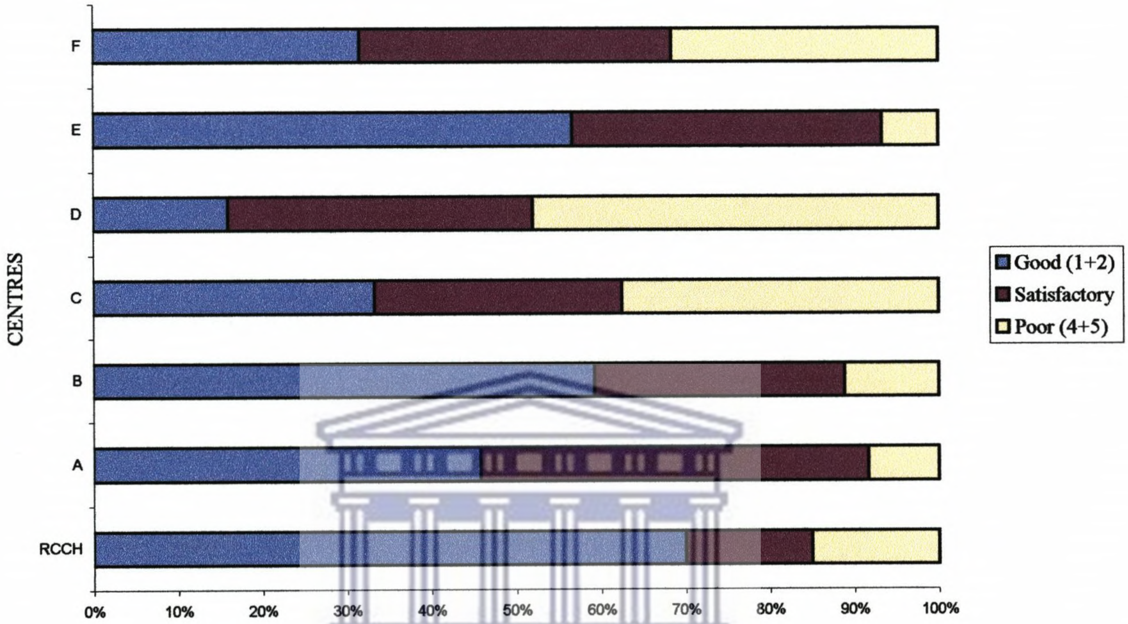


Figure 3. Cumulative Goslon score for the RCCH and the Six-Centre International study.

From the cumulative Goslon score it is evident that more than 80% of the patients from the RCCH (85%) show satisfactory results. This is comparable to the results from centres A (92%), B (89%) and E (94%). On the other hand centre D has nearly 50% of the subjects in Group 4 and 5. Similar poor results were found in centre C (37%) and centre F (32%).

The comparison of the mean Goslon score for the RCCH and the six European centres is summarised in Table 15.

Centre	Number	Mean Goslon	Standard Deviation	95% Confidence Interval	P-value
RCCH	20	2.30	1.20	1.74 - 2.86	-
A	24	2.64	0.64	2.37 - 2.91	0.2369
B	27	2.47	0.66	2.21 - 2.73	0.5374
C	24	3.04*	0.87	2.67 - 3.41	0.0226
D	25	3.46*	0.92	3.08 - 3.84	0.0007
E	30	2.59	0.76	2.31 - 2.87	0.2999
F	19	3.03*	0.75	2.67 - 3.39	0.0295

Table 15. Comparison of centres using the mean and standard deviation of the Goslon scores. (* P< 0.05)

The results of the 95% confidence interval indicate good precision of the sample mean. When comparing the mean score from the RCCH group with the mean from the individual centre using the t-test the results revealed statistically significant differences between the means when comparing RCCH versus centre C (P= 0.0226), RCCH versus centre D (P=0.0007) and RCCH versus centre F (P=0.0295).

CHAPTER SIX

6. DISCUSSION

Intercentre studies have been highlighted by Roberts et al. (1991) as a means of comparison of treatment outcomes. The Eurocleft six-centre international study was a landmark intercentre research project in measuring treatment outcomes for CLP patients. It was designed to allow direct comparison of the outcomes of primary surgery between different units with different techniques and protocols. Although it is impractical for all centres to participate in such a study, the published data of the six-centre international study allows individual centres to compare and audit their own treatment outcomes against a European standard. This study investigated the treatment outcomes of the UCLP children treated at the RCCH with respect to the cephalometric and dental morphology and compared it to those of the six-centre international study.

6.1 Statement of the Principal Findings

Several authors have found the most striking features of the UCLP patients to reside in the maxillae (Šmahel and Brejcha, 1983; Šmahel and Müllerová, 1986; Šmahel et al., 1993; Öztürk and Cura, 1996). The cleft samples have a more retrognathic maxillae, with decreased anteroposterior length and more retroclined incisors. The degree of maxillary growth inhibition implicated in the surgical correction of the cleft lip and palate, would be an important factor when measuring treatment outcomes. The cephalometric parameters measuring maxillary protrusion, length and height, showed no significant difference between the RCCH and the six Eurocleft centres, except with centre D. Centre D showed a significant decrease in maxillary protrusion when compared to the RCCH. A significant difference for posterior height was reported between centre D and centres E and F by Mølsted et al. (1992). A significant increase in the upper incisor inclination was found in the RCCH patients compared to centres B, C, D, and F. Although this result could reflect a difference in surgical management, it could also reflect a difference in the population between the RCCH and the European sample. A significant increase and backward rotation of the maxillary plane relative to the cranial base was also found compared to centres B, C, E and F.

The significant difference in the soft tissue parameters was observed largely with respect to the relative protrusion of the nose and the sagittal soft tissue variable sss-ns-pgs. The RCCH children showed a significant relative retrusion of the nose with respect to the other centres. It has been shown that the characteristic features in the soft tissue profile of operated children with UCLP are, flattening of the nose (Sadowsky et al., 1973) and a short upper lip (Šmahel and Müllerová, 1986). The thickness of the upper lip in children with UCLP has been reported to be decreased (Coccaro and Pruzansky, 1965; Sadowsky et al., 1973;), whereas Šmahel and Müllerová (1986) have reported an increased thickness of the upper lip in children with UCLP. The RCCH group showed no great difference with the six centres with respect to flattening of the nose, upper lip height and thickness.

In the six-centre study centre D differed significantly from the others centres showing rather poor treatment outcomes, which was attributed to the use of extra oral strapping. Similar significant differences were found between the RCCH hospitals and centre D for most of the cephalometric variables. When comparing the cephalometric variables for the RCCH to the better centres (centres A, B and E), no significant difference was found for most of the variables.

The Goslon Yardstick was used to assess the dental arch relationships and surgical treatment outcomes in the RCCH. Shaw et al. (1992b) has shown the Goslon Yardstick to be a more course and robust index better capable of analysing and discerning the quality of results between centres. The yardstick was developed, through the collective views of a group of experienced orthodontists, as a way to measure not only the severity of the malocclusion but also the difficulty associated with its treatment (Mars et al., 1987). The results of the dental analysis in the Six Centre Study showed a significant difference in treatment outcomes between the centres. The overall results showed that the best results were obtained in the two European centres (centres B and E) whereas the two United Kingdom (U.K.) centres (centres C and D) were ranked lowest. The clinical audit in the U.K. by the Clinical Advisory Group (CSAG) also reported poor treatment results in the 57 cleft teams evaluated. They found that 39% of the12 year old UCLP patients surveyed nationally were ranked poor or very poor, 34% as good and 27% as satisfactory. Both studies seem to substantiate earlier claims of mediocrity in the standards of cleft care in the U.K. The recent studies by Leonard et al. (1998) and Morris et al. (2000) show a more favourable Goslon score in their studies evaluating the dental arch relationship of Northern Irish and Yorkshire UCLP children respectively. Leonard et al (1998) reported that 72% of their sample had a good or satisfactory dental arch relationship, which fell halfway between the best and the worst of the Eurocleft centres. Morris et al. (2000) similarly found 68.5% of the UCLP patients from West Yorkshire with good or satisfactory arch relationship.

The results of the Goslon Yardstick for the RCCH faired favourably with the better centres in the six-centre study. The mean Goslon scores revealed no significant difference between the RCCH and the centres E, A and B. A significant difference was found between the RCCH and centres C, D, and F, which were ranked lowest in the six-centre study. The cumulative Goslon score for the RCCH showed that 85% of the UCLP were ranked as good or satisfactory compared to 89% in centre B and 94% in centre E. On the other hand centre D had nearly 50% of the patients ranked as poor with similar results obtained in centre C (37%) and centre F (32%). A significant proportion of the patients in the RCCH group had a Goslon score ranked as good (70%) compared to centres A (46%), B (60%), and E (57%). Furthermore 30% of the patients in the RCCH group had a Goslon score of 1, whereas none were recorded for centres A, B, D and F and only one each in centres C and E in the six – centre study.

6.2 Strength and Weakness of the study

Shaw et al. (1992) reported on the weak sensitivity of cephalometric analysis to statistically discern significant differences between centres for the age and size of the samples included. This study has reinforced the limited ability of cephalometric analysis to detect significant differences in the quality of outcome of UCLP children in different centres. Although clear differences were found in the mean cephalometric values from the different centres, the variability of the cephalometric data prevented these from reaching a level of statistical significance.

In addition Shaw et al. (1992b) highlighted the limitations of the cephalometric technique, identification of landmarks and the difficulty of pooling films from different centres where equipment and exposures vary widely. It must be realised that the cephalometric radiology is far from standardised between centres. In the original six-centre study only two centres had cephalometric units with identical specifications.

The cephalometric radiographs used in this study were standardised and the quality of the radiographs showed good contrast, density and sharpness, allowing good visualisation of the cephalometric landmarks.

Furthermore, computer technology can facilitate the cephalometric analysis, but it may also introduce an additional source of error. Such errors can also be related to the digitiser where discrepancies are shown to occur with respect to resolution accuracy, and linearity (Eriksen and Solow, 1988 – cited in Mølsted et al., 1992).

The digitising process used in this study was quite acceptable with respect to resolution accuracy and linearity.

The dental arch relationships when compared with the Golson Yardstick appeared to provide more useful data and is more capable of discerning between centres more sensitively than the cephalometric analysis. In addition the Goslon technique has the added advantage of assessing dental arch growth restriction in all three dimensions. The separation of the outcome categories into three groups (good, satisfactory, or poor) is particularly useful especially in clearly identifying those UCLP children likely to require orthognathic intervention.

Although the methodology and the measurement techniques in this study were similar to those used in the Eurocleft study, the potential for inter observer error must be acknowledged when comparing the results of this study to the published Eurocleft data.

This study was restricted to an assessment of the facial growth of UCLP children treated at the RCCH. Factors such as nasolabial appearance, speech and hearing are important in the overall evaluation. In the Eurocleft study, an assessment of nasiolabial appearance was carried out using frontal and profile photographs of the nasolabial area (Asher-McDade et al., 1992). It was not possible to carry out this assessment because photographs were not routinely taken at the age of cephalometry.

Furthermore, in order to obtain a comprehensive description of the morphology of cranial anomalies, it is necessary to add additional radiographic projections, particularly if symmetry of the face is affected.

6.3 The Meaning of the Study and Possible Clinical Implications

The dental arch relationship and craniofacial form for the RCCH ranked favourably with the best centres (centre B and E) in the six-centre study. The clinical management differed between theses centres with respect to staging of closure. Whereas at centres B and E the lip and palate were closed in two stages, patients at the RCCH were managed with a one stage primary repair of the lip and palate. Thus the one stage procedure, which is implicated in growth inhibition, did not adversely affect the treatment outcomes of the RCCH patients. Ross (1987g) and Shaw et al. (1992) also attributed the surgeons experience and caseload as important factors in the treatment outcomes achieved in the six centres in the Eurocleft study. Centres with a high case load as seen in centres B and E ranked high in the quality of results, whereas centres C and D with a large number of low volume operators ranked lowest. For example the single surgeon in centre B treated 54 UCLP patients over a 3-year period, and over the same period 83% of the 12 surgeons in centre D treated three or fewer. In the RCCH, a single surgeon managed the primary care for 19 of the 20 patients over the 4-year period, thus giving further credence to this hypothesis.

6.4 Future research and recommendations

This study provides an introduction to the evaluation of treatment outcomes of UCLP patients. Since this anomaly requires multidisciplinary care, a comprehensive assessment of various aspects of treatment outcomes needs to be established. This should include an assessment of the success of alveolar bone grafting, facial aesthetics, speech and hearing, and psychosocial status together with patient satisfaction. Clearly, as outcomes for speech, hearing facial appearance and psychosocial well-being are developed it will be important to integrate all facets to determine quality of cleft care. Moreover, the earlier these measures can be detected the sooner rational changes to protocols can be made where the quality of outcome is poor. Mackay et al. (1994) and Atack (1998) have shown that using soft tissue form and dental analysis respectively as a measure of treatment outcome, it is possible to detect differences in surgical outcome earlier at 5 years of age. Evaluation prior to 'contamination' by orthodontic treatment or alveolar bone grafting is also likely to yield a truer assessment of the primary surgery. Furthermore, 5-year record taking is a recommendation of the International Committee on Cleft Documentation and Measurements (Lee, 1993 – cited in Johnson et al., 2000).

CHAPTER SEVEN

7. CONCLUSION

The treatment outcome of children treated at the RCCH was evaluated with respect to craniofacial form and dental arch relationship. When comparing the mean cephalometric skeletal parameters of the RCCH to the six centres in the Eurocleft study, a significant difference was found between the RCCH group and centre D for most of the variables. A significant increase in the upper incisor inclination and maxillary inclination was found in the RCCH patients compared to the European centres. The difference in the soft tissue parameters was limited to the relative protrusion of the nose and the sagittal soft tissue variable sss-ns-pgs.

Analysis of the Goslon scores showed that the RCCH group was comparable to the better centres (centre A, B and E) in the six-centre study. A significant difference was found between the Goslon score for the RCCH and centres C, D, and F who faired worst in the six-centre study.

APPENDIX A

Cephalometric skeletal reference points

ai Apex inferius. The apex of the root of the most prominent lower central incisor.

ar Articulare. The point at the intersection between the contours of the mandibular ramus and occipital bone.

as Apex superius. The apex of the root of the most prominent upper central incisor.

ba Basion. Most posteroinferior point on the clivus bone.

gn Gnathion. The most inferior point on the mandibular symphysis furthest from nasion.

id Infradental. The most anterosuperior point on the lower alveolar margin.

ii Incision inferius. The midpoint of the incisal edge of the most prominent lower central incisor.

is Incision superius. The midpoint of the incisal edge of the most prominent upper central incisor.

n Nasion. The most anterior point on the frontonasal suture.

pg Pogonion. The most anterior point on the mandibular symphysis.

pgn Prognathion. The point on the mandibular symphysis farthest from ar.

pm Pterygomaxillare. The intersection between the nasal floor and the posterior contour of the maxilla.

pr Prosthion. The most anteroinferior point on the upper alveolar margin.

s Sella. The center of the sella turcica.

sm Supramentale (B-point). the deepest point on the anterior contour of the lower alveolar process.

sp Spina nasalis anterior. The apex of the anterior nasal spine.

ss Subspinale (A-point). The deepest point on the anterior contour of he upper alveolar arch.

tgo Gonion tangent point. Point of intersection between the mandibular line and the ramus line.

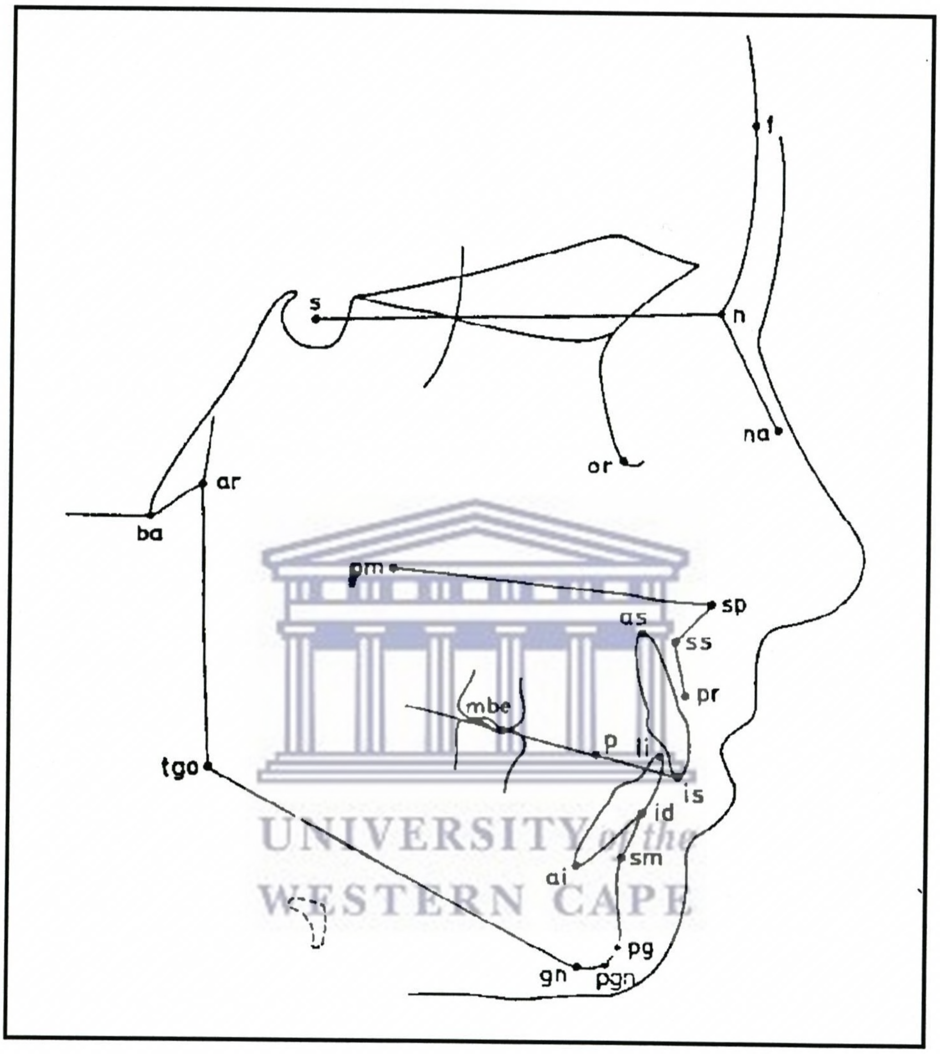


Figure A1. Cephalometric Skeletal points and reference lines

Cephalometric soft tissue reference points

gs Soft tissue glabella. The most anterior point on the soft tissue glabella.

gns Soft tissue gnathion. The sotft tissue point overlying gn.

li Labrale inefrius. The most prominent point on the prolabium of the lower lip.

ls Labrale superius. The most prominent point on the prolabium of the upper lip.

ns Soft tissue nasion. The deepest point in the frontonasal curvature estimated from NFL.

nst Nasal septum tangent point. The anterior tangent point of the tangent to the nasal septum through sn.

pgs Soft tissue pogonion. The most prominent point on the chin.

pgns Soft tissue prognathion. The soft tissue point overlying pgn.

prn Pronasale. The ost prominent point on the apex of the nose.

sms Soft tissue supramentale. The point off greatest concavity in the midline of the lower lip between labrale inferius and soft tissue pogonion.

sn Subnasale. The deepest point in the nasolabial curvature.

sss Soft tissue subspinale. The deepest of greatest concavity or convexity in the midline of the upper lip between subnasale and labrale superius.

stu Stomion (upper lip). The deepest point of the upper lip in rima oris.

stl Stomion (lower lip). The deepest point of the lower lip in rima oris.

unt Upper nasal tangent point. The nasal tangent point of the nasofrontal line (NFL).

Cephalometric skeletal reference lines

ILi Axis of lower incisors. A line from ii to ai.

ILs Axis of upper incisors. A line from is to as.

ML Mandibular line. The tangent to the lower border of the mandible through gn.

NL Nasal line. The line through sp and pm.

NSL Nasion-sella line. The line through n and s.

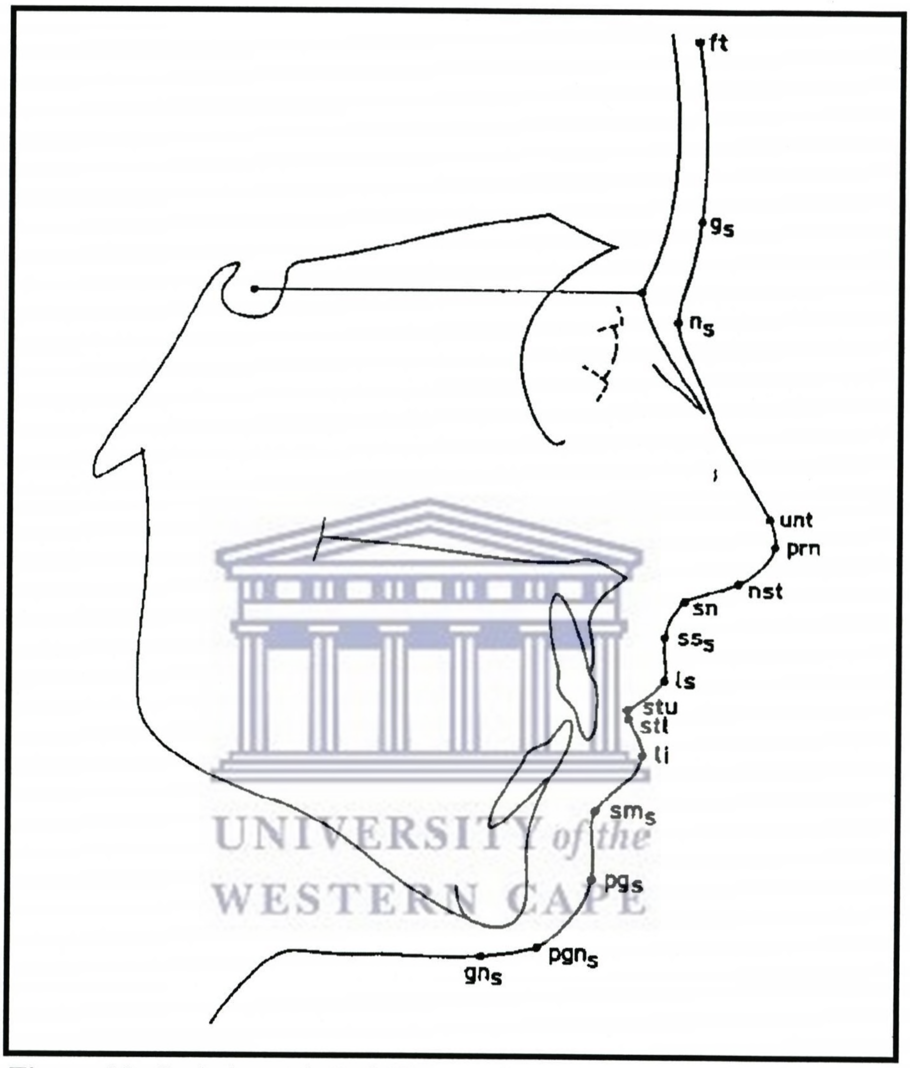


Figure A2. Cephalometric Soft Tissue points

Cephalometric skeletal parameters

s-n-ss;	pm-ss;	s-pm;	n-sp
NSL-NL;	s-n-pg;	NS-ML;	Ils-NL

Cephalometric soft tissue parameters

unt-ns-sss;	ns-unt/NSL;	ns-prn-sn;	sn-stu;
nst-sn-ls;	sss-ss;	li-id;	li-sms-pgs;
sss-ns-sms;	sss-ns-pgs;	gs-prn-pgs	

APPENDIX B

Goslon Yardstick:

The Goslon Yardstick is a five grade categorical scale that compares the dental arch relationships of UCLP patients with those of a master set of study models arranged in five groups, from the very best dental arch relationships (Goslon group 1) to the worst (Goslon group 5).

Group 1: - excellent dental arch relation.
- requires either straight forward orthodontic treatment or none at all.

Group 2: - good dental arch relation.
- requires either straight forward orthodontic treatment or none at all.

Group 3: - fair dental arch relation.
- require complex orthodontic treatment to correct Class III malocclusion and possibly other arch malrelationships.

Group 4: - poor dental arch relation.
- at the limits of orthodontic treatment without orthognathic surgery.
- if facial growth is unfavourable, orthognathic surgery will be required.

Group 5: - very poor dental arch relation.
- require orthognathic surgery to correct skeletal malrelationships.

Application of the Yardstick:

Stage 1: Anteroposterior Assessment

The overjet is examined first. If for example there is a reverse overjet of 3 to 5 mm, this indicates that the case might belong to group 4. However, if there is already dentoalveolar compensation with marked proclination of the upper incisors and retroclination of the lower incisors indicating that the overjet underestimates the severity of the case, a higher category should be considered. For example, 4+ might then be provisionally allocated at this stage. On the other hand, if the inclinations of the incisors or if overclosure of the mandible exaggerates the severity of the reverse overjet, this should be taken into account and a less severe category than might originally have been considered, may be appropriate. The anteroposterior relationships of the buccal segments are not of importance in determining the grouping of a case.

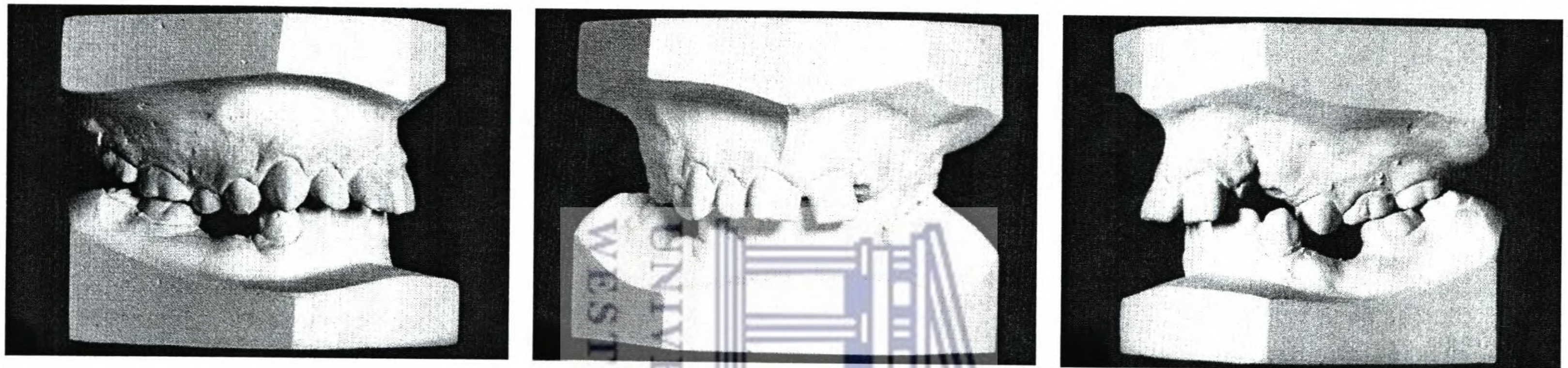
Stage 2: Vertical Assessment

Favourable vertical features (i.e., deep overbite) do not indicate a modification of the provisional category except in borderline cases. A reduced overbite or anterior openbite suggests a higher grouping. For example, a case placed at the borderline between groups 3 and 4 on the anteroposterior assessment, but with a deep overbite might be confirmed as belonging to group 3. On the other hand, a case provisionally grouped a 3 but with an anterior openbite would probably be transferred to group 4 at this stage.

Stage 3: Transverse Assessment

A normal transverse relationship or a crossbite that can be treated orthodontically does not indicate a change of group. Marked narrowing of the upper arch with bilateral crossbite could indicate a more severe category for a case already at the upper limits of a group for other reasons.

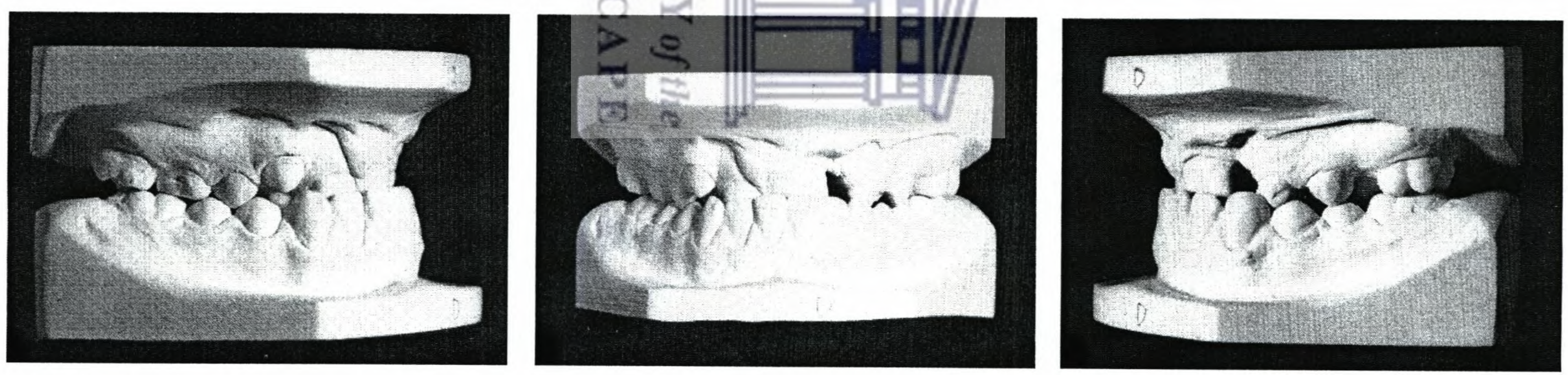
Goslon Yardstick Models



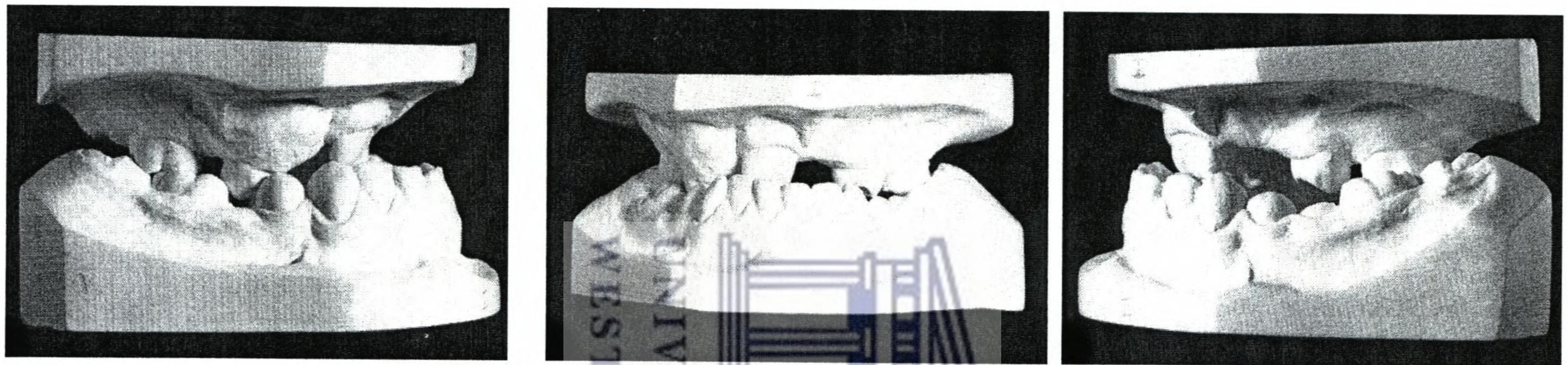
Goslon Group 1

Goslon Group 2

Goslon Group 3



Goslon Group 4



Goslon Group 5

APPENDIX C

Cephalometric Raw Data

No.	s-n-ss	pm-ss	s-pm	n-sp	NSL-NL	s-n-pg	NSL-ML	I1s- NL
1	78.32	42.75	36.30	48.29	18.01	74.41	36.88	101.12
2	78.30	44.99	26.71	42.12	21.11	73.42	43.51	109.49
3	74.85	42.33	37.74	46.48	12.16	75.91	35.47	109.09
4	76.91	39.01	30.14	39.96	14.70	71.24	43.02	101.31
5	77.93	41.13	24.32	33.72	13.74	78.93	37.92	104.60
6	81.20	42.41	35.29	40.62	10.19	75.40	44.27	112.38
7	74.77	44.80	35.88	47.35	15.17	71.84	35.63	100.39
8	82.38	49.02	43.58	48.05	7.30	77.41	30.14	105.51
9	75.74	42.73	37.02	49.72	16.68	74.68	39.77	101.45
10	76.93	38.69	37.80	42.78	9.92	77.89	34.67	102.93
11	82.75	44.26	35.79	42.10	12.39	77.49	32.70	113.97
12	75.47	42.66	40.41	47.71	9.82	75.33	43.55	110.80
13	81.39	48.75	43.26	46.05	3.99	75.69	39.34	103.46
14	82.99	46.46	29.93	43.25	20.63	78.32	35.71	114.20
15	77.68	40.61	33.80	46.15	16.46	73.11	48.29	90.74
16	78.10	42.78	38.20	48.52	15.44	76.23	42.68	120.48
17	77.09	42.71	39.42	45.61	11.03	76.11	34.77	96.22
18	81.89	49.99	39.52	48.13	10.22	73.52	45.04	109.27
19	77.98	42.92	33.64	41.41	12.53	72.07	37.70	110.28
20	75.34	43.24	40.63	46.88	8.06	76.62	38.89	96.80

Table A1. Cephalometric skeletal measurements

No.	unt-ns-sss	ns-unt/NSL	ns-prn-sn	sn-stu	nst-sn-ls	sss-ss	li-id	li-sms-pgs	sss-ns-sm	sss-ns-pgs	gs-prn-pgs
1	25.93	112.04	101.91	15.49	108.31	13.46	17.60	122.36	9.67	7.17	145.15
2	17.48	106.10	105.28	19.01	90.53	12.12	15.71	147.49	9.14	11.26	150.29
3	21.14	103.14	109.24	17.80	96.37	9.90	12.90	143.52	3.19	3.45	153.24
4	21.18	104.56	108.48	15.26	93.51	11.15	15.39	121.60	7.38	6.31	150.35
5	26.70	110.43	102.42	15.88	94.12	9.32	11.82	136.89	3.08	2.60	151.50
6	19.85	111.16	108.33	18.30	116.25	14.62	15.34	166.64	8.25	10.06	146.07
7	20.25	101.65	108.59	17.56	112.72	9.87	13.93	136.06	7.14	5.76	146.55
8	22.43	109.89	103.78	17.12	89.36	8.80	17.76	122.31	7.83	7.17	147.58
9	22.64	105.98	107.75	18.75	108.25	11.38	16.30	110.11	7.42	5.71	144.58
10	24.65	111.35	110.44	16.86	116.60	12.88	15.08	139.53	3.77	3.64	153.27
11	20.90	111.82	101.91	18.86	98.10	11.70	16.54	142.79	7.77	8.48	144.84
12	21.49	105.19	105.35	19.96	88.63	13.86	19.03	136.93	4.35	4.19	151.75
13	26.27	114.69	96.23	21.18	89.51	14.63	20.06	120.35	9.90	9.63	142.73
14	18.64	109.86	105.79	17.58	106.24	11.13	11.89	158.61	9.45	9.95	149.21
15	16.29	98.95	115.91	15.06	117.46	10.00	14.87	166.55	5.00	6.39	148.17
16	18.08	104.99	94.61	14.04	62.69	15.95	20.35	131.35	7.49	7.89	136.10
17	18.12	103.29	110.91	20.05	106.50	11.54	16.23	128.72	6.65	4.94	152.66
18	17.73	107.30	115.23	20.28	101.91	11.62	19.35	126.58	10.84	11.78	150.42
19	16.38	103.65	108.04	18.13	88.85	11.45	16.59	125.39	8.93	8.98	151.69
20	25.55	109.53	102.44	20.07	108.10	12.61	16.56	149.05	3.37	3.76	148.35

Table A2. Cephalometric soft tissue measurements

No.	s-n-ss	pm-ss	s-pm	n-sp	NSL-NL	s-n-pg	NSL-ML	I1s- NL
3	74.85	42.33	37.74	46.48	12.16	75.91	35.47	109.09
9	75.74	42.73	37.02	49.72	16.68	74.68	39.77	101.45
11	82.75	44.26	35.79	42.10	12.39	77.49	32.70	113.97
16	78.10	42.78	38.20	48.52	15.44	76.23	42.68	120.48
17	77.09	42.71	39.42	45.61	11.03	76.11	34.77	96.22
No.	**unt-ns-sss**	**ns-unt/NSL**	**ns-prn-sn**	**sn-stu**	**nst-sn-ls**	**sss-ss**	**li-id**	**li-sms-pgs**
3	21.14	103.14	109.24	17.80	96.37	9.90	12.90	143.52
9	22.64	105.98	107.75	18.75	108.25	11.38	16.30	110.11
11	20.90	111.82	101.91	18.86	98.10	11.70	16.54	142.79
16	18.08	104.99	94.61	14.04	62.69	15.95	20.35	131.35
17	18.12	103.29	110.91	20.05	106.50	11.54	16.23	128.72

No.	sss-ns-sm	sss-ns-pgs	gs-prn-pgs
3	3.19	3.45	153.24
9	7.42	5.71	144.58
11	7.77	8.48	144.84
16	7.49	7.89	136.10
17	6.65	4.94	152.66

Table A 3. Cephalometric measurements for the 5 repeat tracings

APPENDIX D

Letter of consent to use clinical records and material at the RCCH.

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