10 A 25-Year Longitudinal Facial Growth Study of Unilateral Cleft Lip and Palate Subjects from the Sri Lankan Cleft Lip and Palate Project

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10.1 Introduction and Background

The Sri Lankan Cleft Lip and Palate Project (SLCLPP) was founded in 1984 and completed data collection in 2009. Surgical visits were undertaken in 1985, 1986 and 1990. More than 500 surgical patients have been followed up longitudinally for 25 years post-operatively, resulting in the creation of a unique multidisciplinary archive. In total, 14 data collection visits were made from 1984 to 2009 (Mars et al. 2008).

Patients presented for surgery at all ages from infancy to adulthood. Many had received no surgery whatsoever; some had received lip surgery but not palatal surgery and others lip and palate surgery by local surgeons. They therefore provided a special opportunity to study the nature and timing of surgical intervention and its outcome on facial growth up to adulthood (nature's experiment).

This chapter is an analysis of the long-term outcome of patients who were over 20 years of age at their last data collection point.

10.1.1 Records Collected for Study

Standardised lateral skull radiographs and dental study models were collected for all subjects as part of this longitudinal study. Impressions were taken in alginate material with the patients sitting upright on a wooden chair.

10.2 Un-operated Unilateral Cleft Lip and Palate

Adults with un-operated clefts of the lip and palate provide the ideal group to study the natural progression of facial growth and to fully assess the inherent growth potential in these patients. Due to the ethical difficulties in withholding treatment for cleft patients, studies of un-operated cleft subjects have been undertaken in the developing world where surgery has not been readily available. As a result, most studies on such patients have lacked a suitably matched local comparison group as most operated patients presented from the developed world (Mars 1993).

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10.2.1 Clinical Features

The most striking feature in the un-operated UCLP patient is the protrusion of the upper labial segment (Fig. 10.1). These subjects present with large overjets, proclined upper incisors, eversion of the major segment, mild contraction of the lesser segment in the anterior region and rarely, buccal crossbites.

10.2.2 Cephalometry

Using the Sri Lankan growth archive, Liao and Mars (2005a) studied the long-term effects of clefts on craniofacial morphology in patients with UCLP. Employing a retrospective case–control study design, they compared 30 un-operated adult UCLP patients with 52 normal (non-cleft) control subjects of the same ethnic background. Cephalometric analysis confirmed the presence of morphological differences between UCLP and non-cleft patients (Fig. 10.2). The adverse effects of clefting were predominantly on the vertical development of the maxilla both anteriorly and posteriorly and to a lesser extent on the anteroposterior development of the basal maxilla. In addition, there were differences in the position and shape of the mandible and the position of the maxillary and mandibular incisors. However, the overall anteroposterior dimensions of the maxilla were not affected by clefting, and these patients did not exhibit maxillary retrusion.

10.2.3 Study Model Analysis

Using the reflex microscope, McCance et al. (1990) studied the maxillary arch form of 41 adults with un-operated complete unilateral cleft lip and palate and compared them to a control group of 100 normal adults (Fig. 10.3).

The teeth in the cleft group were smaller than their equivalents in the control group, the most marked difference being found in the central and lateral incisors. Arch widths of the cleft groups were reduced, more anteriorly (5 mm in the canine region) than posteriorly (1.6 mm in the second molar region), resulting in more V-shaped arches. No differences were found in the arch length or chord lengths between the groups. There was a higher prevalence of crossbites in the cleft group, 19.5 %, compared to none of the controls, and the overjet was greater in the cleft group (mean 8.2 mm) than in the controls (3.7 mm). A higher percentage of missing teeth, most commonly the lateral incisor teeth, was recorded in the cleft group. There was no difference in crowding between the two groups. Although the reductions in tooth size and arch width would suggest a small degree of primary hypoplasia, the differences are small.

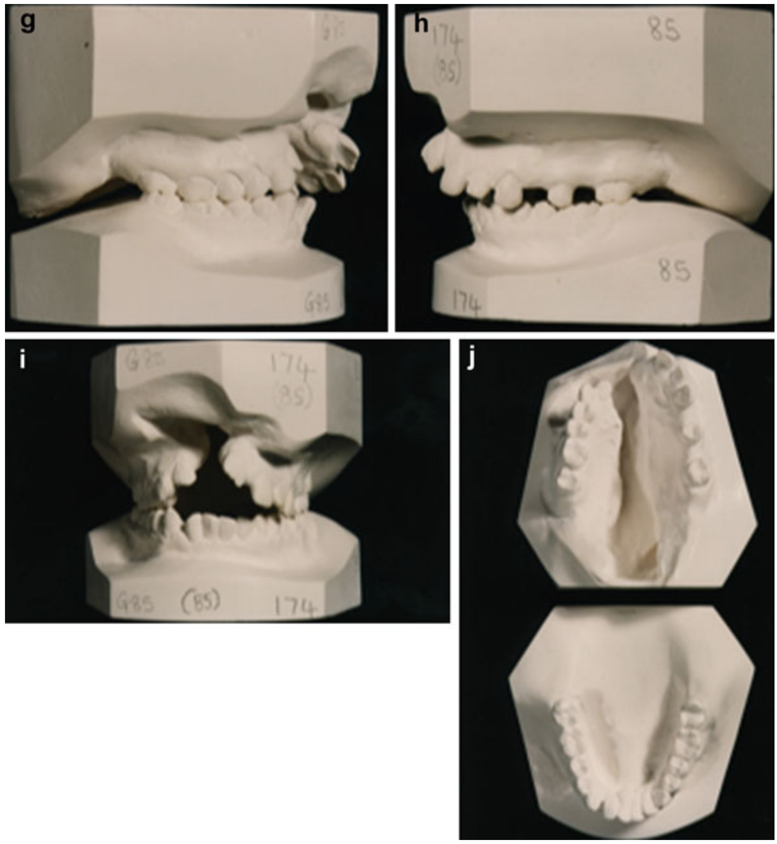
The GOSLON yardstick is a robust and reproducible tool for categorising dental arch relationships into five distinct groups of increasing deformity (Mars and Plint 1985, Mars et al. 1987). It was applied to 51 un-operated UCLP cases, and the results showed 98 % of the cases were in groups 1 and 2 (excellent or very good arch relationships) and no cases in groups 4 or 5 (Fig. 10.4). In contrast, only a small proportion of operated patients were in group 1 when UK centres were assessed as part of the CSAG study (Clinical Standards Advisory Group 1998) (Fig. 10.5).

10.2.4 Summary

Studies using cephalometry and study models confirm that there is an intrinsic potential for un-operated UCLP patients to grow relatively normally with minor distortions around the cleft site itself where the dentition is unrestrained because of the disrupted musculature. In addition, the lack of continuity of the arch probably explains the transverse distortions seen in the dental arch. There is a small degree of hypoplasia as discussed above but these are minor and do not account for the gross maxillary retrusion frequently reported in surgically repaired patients.

Fig. 10.1 (**a**–**j**) Illustrates a typical example of the facial appearance and dental study models of an un-operated unilateral cleft lip and palate case

Fig. 10.1 (*continued*)



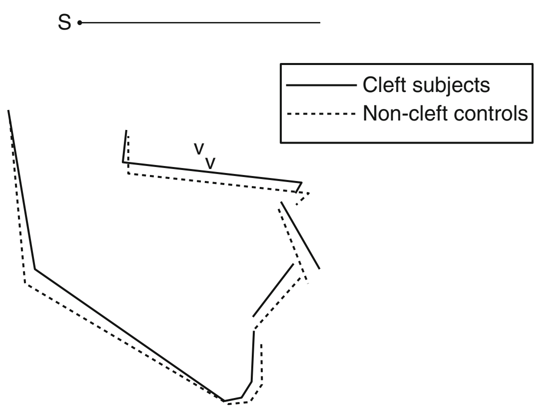


Fig. 10.2 Dental and skeletal effects of lip surgery (Liao and Mars 2005a)

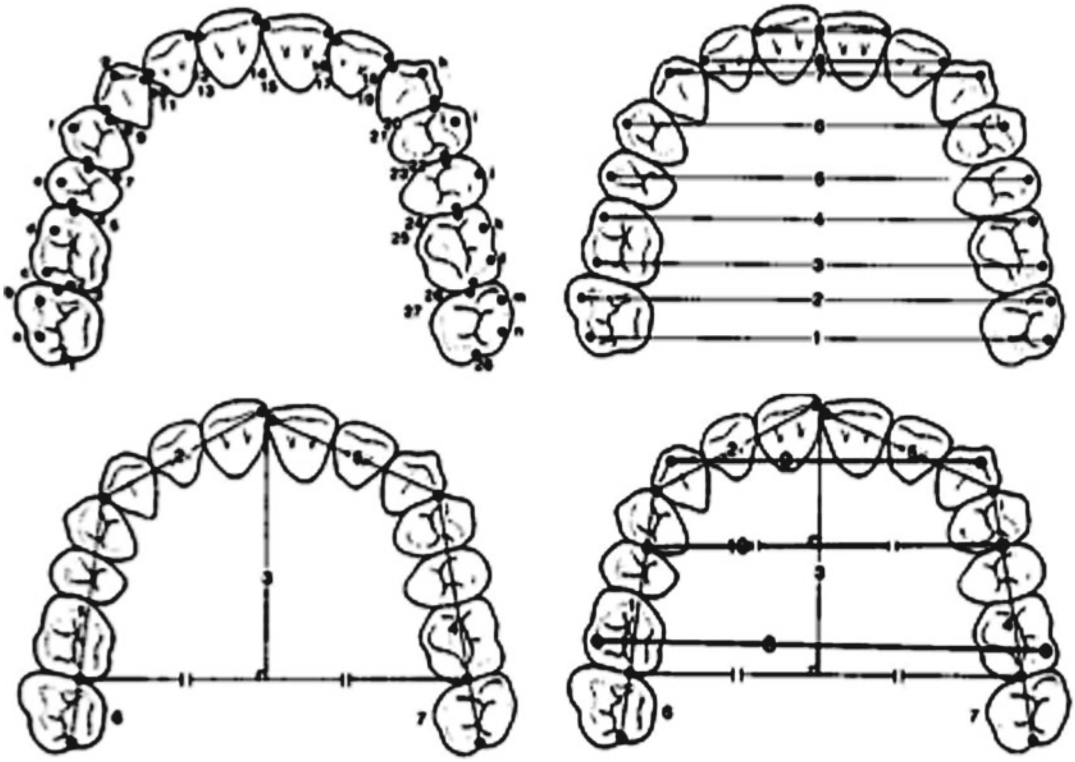


Fig. 10.3 The digitised points, chord lengths and arch widths used in the reflex microscopic analysis of study models

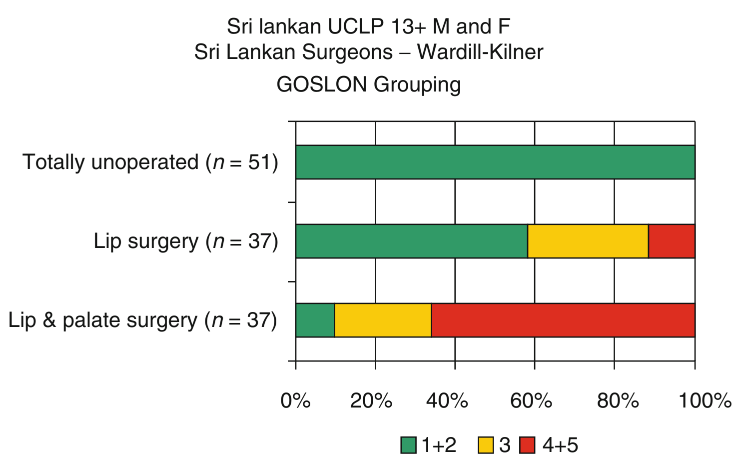


Fig. 10.4 GOSLON grouping of UCLP patients operated by Sri-Lankan surgeons using Wardill-Kilner (Mars and Houston 1990)

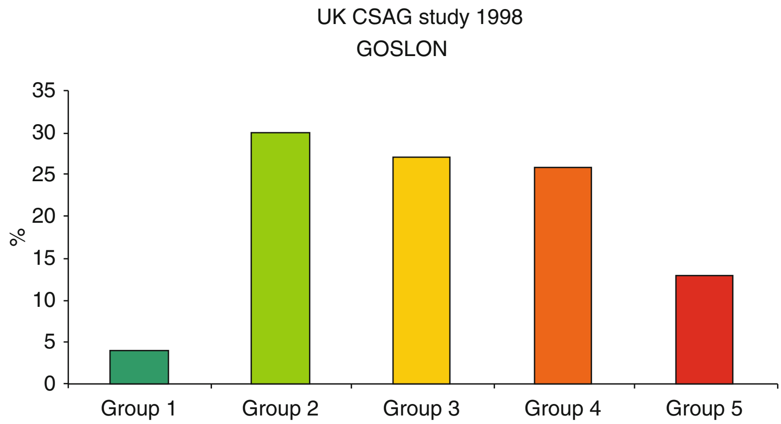


Fig. 10.5 GOSLON for the 1998 CSAG (Clinical Standards Advisory Group) for the whole of the UK

10.3 Effect of Primary Surgery on Facial Growth

It is widely accepted that facial growth and morphology in cleft lip and palate patients is abnormal, with mid-face retrusion common in patients who have had corrective surgery in infancy (Ross 1987; Semb 1991).

Historically, the cause of this mid-face retrusion has been attributed to three possible causes: an intrinsic developmental deficiency, functional distortions affecting growth and iatrogenic factors due to surgical treatment. There has been significant controversy on the extent and relative contributory role of each of these possible causative factors. It was this unresolved conflict of opinions on the aetiology of facial growth distortion in operated cleft lip and palate patients that led to the establishment of the SLCLPP.

A number of seminal papers on facial growth in cleft patients have been published from the Sri Lankan archives.

Mars and Houston (1990) reported the effects of primary lip and palate surgery on craniofacial growth in cleft patients using a cohort of Sri Lankan male patients. The studied patients were divided into three subgroups and compared to a control group of healthy males using lateral cephalometry and study model analysis. The three subgroups analysed included: those who had totally unrepaired cleft lip and palate, those who received lip repair in infancy but not palatal repair and those who had lip and palate repair in infancy. From this preliminary study, it was clearly evident that un-operated cleft patients had the potential to grow normally. Furthermore, in patients who have had a lip repair but no palate repair, the maxilla appears to also grow relatively normally.

In addition to cephalometry, Mars and Houston (1990) applied the GOSLON yardstick to the same cohort of patients aged 13 years old operated by Sri Lankan surgeons. Figure 10.4 shows that all the subjects in the totally un-operated subgroup had excellent dental arch relationships (groups 1 and 2). In the lip only subgroup, almost two thirds of the subject scored in groups 1 and 2, and only a small proportion scored in groups 4 and 5. This contrasts markedly with the lip and palate subgroup where two thirds of the patients were in groups 4 and 5 (poor dental arch relationship) and only a small proportion in groups 1 and 2.

Using preliminary data from the SLCLPP, Mars and Houston (1990) clearly showed the detrimental effects of primary palatal surgery on facial growth.

We now have complete data for 198 UCLP subjects who are greater than 20 years of age. This chapter studies the GOSLON yardstick analysis of all these patients and the cephalometric measures for 154 subjects.

10.3.1 Lip Surgery

Whilst studies on un-operated cleft patients have demonstrated the iatrogenic effects of primary

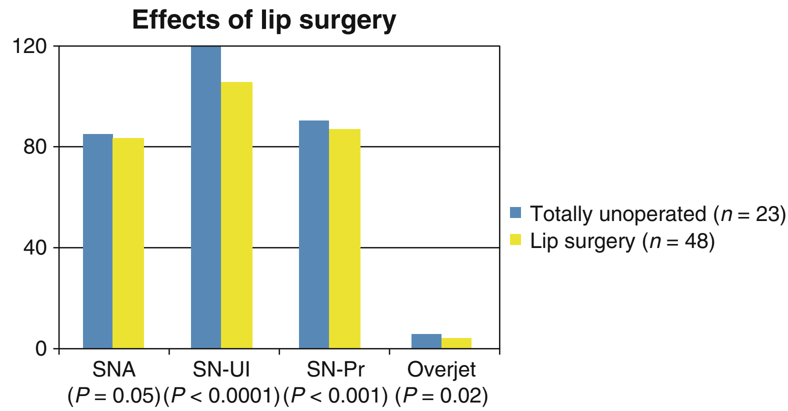


Fig. 10.6 Effects of Lip Surgery (Liao and Mars 2005b)

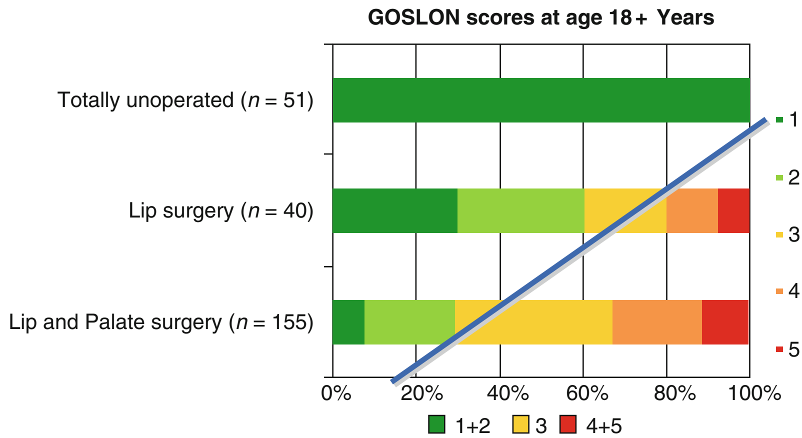


Fig. 10.7 The diagonal line demonstrates the progressively worsening effect from no surgery to lip surgery to lip and palate surgery

cleft surgery on facial growth, there has been controversy as to whether the lip or the palate repair has the most detrimental effect on maxillary growth (Muir 1986; Mars and Houston 1990; Bardach et al. 1984).

10.3.1.1 Cephalometry

Liao and Mars (2005b) further clarified the long-term effects of lip surgery on craniofacial growth. Using lateral cephalograms from the longitudinal growth data obtained from the SLCLPP, they studied 71 adult patients, 23 non-syndromic unoperated UCLP patients and 48 non-sydromic UCLP patients who had undergone lip repair only. This study demonstrated that the major effect of the lip repair was on the anteroposterior and vertical position of the maxillary alveolus and the maxillary incisors. Furthermore, there was a differential influence from the tip of the alveolus and the incisal edge to the base of the alveolus and the incisal apex. This was associated with uprighting of the maxillary incisor and resulted in a decreased overjet and increased overbite in the lip repair only group (Fig. 10.6). The pressure of the lip thus produces secondary bone resorption in the base of the anterior maxillary alveolus.

10.3.1.2 Study Model Analysis

More recently, the authors carried out a review of the SLCLPP archive using the GOSLON yardstick. All patients were operated within the project and are now adults aged over 20 years and have completed facial growth. The subjects were divided into the same three subgroups as reported by Mars and Houston (1990) and had had their surgery at varying ages. Interestingly, the same results were replicated. Figure 10.7 below is almost a replica of Fig. 10.4 above.

Both GOSLON figures (Figs. 10.4 and 10.7) clearly demonstrate that surgery to the lip only has some effect, but this is mainly dentoalveolar. The most obvious difference is seen in the patients who have undergone both lip and palate repair, clearly suggesting that the palate repair has the most significant influence on future facial growth.

Muthusamy (1998) analysed study models of 26 patients pre and post lip repair using the reflex microscope. These patients had not had any other surgical interventions and were operated on by British surgeons as part of the SLCLPP.

The patients were divided into two subgroups – young being those who had the lip repair prepubertally (15 patients) and mature being those who had it post-pubertally (11 patients).

He found that in both groups, there was a significant reduction in arch width with the greatest reduction in the inter-canine distance. Interestingly, in the younger group, there was a reduction in arch width in all measures (anterior and posterior), whereas in the mature group, there was no significant reduction in the inter-molar and inter-premolar.

After the lip repair, there was a reduction in overjet and an increase in overbite in both groups (Fig. 10.8).

10.3.1.3 Summary

Both the cephalometric and study model studies confirm that that lip repair primarily produces a localised bone-bending effect on the anterior maxillary alveolus (alveolar moulding) and does not have a significant effect on maxillary growth.

10.3.2 Palate Surgery

Gillies and Fry (1921) were the first to suggest that the palate repair has a detrimental effect on facial growth. Interestingly, they were also the pioneers for the policy of delayed hard palate closure. The SLCLPP has been key in demonstrating the relative effects of lip and palate surgery on future facial growth.

10.3.2.1 Cephalometry

Liao and Mars (2005c) looked at the long-term effects of palatal surgery on facial growth. They compared non-syndromic UCLP Sri Lankan adults who had had either a lip repair only (48 patients) or a lip and palate repair (58 patients) using cephalometry. They concluded that palate repair inhibits the forward displacement of the basal maxilla and anteroposterior development of the maxillary alveolus in patients with UCLP. However, they found that the palate repair did not have any detrimental effects on the downward displacement of the basal maxilla or on palatal remodelling in patients with a unilateral cleft lip and palate. Contrary to expectations, the axial inclination of the maxillary incisors is not affected by the palate repair, though is a major effect of the lip repair as discussed above.

10.3.2.2 Study Model Analysis

Both GOSLON charts (Figs. 10.4 and 10.7) above show that the most obvious difference is seen in the patients who have undergone both lip and palate repair, clearly suggesting that the palate repair has the most significant influence on future facial growth.

10.4 Timing of Primary Surgery and Its Effects on Facial Growth

Because patients presented at all ages for primary surgery, it became possible to analyse the effects of such surgery when performed at any age between infancy and adulthood.

10.4.1 Timing of Lip Surgery

In another cephalometric study, Liao and Mars (2006) looked at the timing of lip repair and the relevance of the operating surgeon. Although the sample size was small (23 in the early repair group and 25 in the mature repair group), they noted that early lip repair was found to produce a greater bone remodelling effect in the base of the anterior maxilla. This is possibly related to the relatively greater surgical trauma in a smaller individual or the early onset on tension from the repaired lip or both. In this study, dentofacial morphology was unrelated to the surgeon who performed the lip repair.

Fig. 10.8 An adult patient who had a lip repair but no palate repair demonstrating the localised effects of lip surgery

Fig. 10.9 Effect of timing of hard palate repair on maxillary growth (Liao et al. 2006)

Timing of hard palate repair

Dependant veriable	Regression coefficient (95% CI)	*P* Value
PMP – A point (mm) Maxillary length	0.2 (0.0,0.4)	0.05
SNA (°) Maxillary protrusion	0.4 (0.2,0.7)	<0.001
ANB (°) Relative maxillary/ Mandibular protrusion	0.4 (0.2,0.6)	0.001

The regression coefficient indicates the change in mean (mm or degrees) of the dependant variable at 20 years of age per year increase at hard palate repair.

In summary, patients with earlier lip repairs display more localised bone remodelling than those operated upon later. As the lip repair only has a localised effect, it probably explains why dentofacial morphology is unrelated to the surgeon carrying out the lip repair.

10.4.2 Timing of Palatal Surgery

As the SLCLPP archive has patients operated on at different ages, it has provided an opportunity to undertake longitudinal retrospective studies to assess the question of the timing of hard palate surgery and its effects on facial growth.

10.4.2.1 Cephalometry

Liao et al. (2006) analysed the longitudinal records for 104 patients non-syndromic UCLP patients who had had their hard palate repair by the age of 13 years. A total of 290 lateral cephalograms taken at different ages were analysed using a linear regression model. The timing of hard palate surgery had a significant effect on the length and protrusion of the maxillary alveolus and the anteroposterior jaw relation measured at 20 years. The regression model suggested a maxillary growth improvement of 0.2mm in maxillary length and 0.4° in both SNA and ANB for every year delay in hard palate closure – Figs. 10.9, 10.10, 10.11, and 10.12. They concluded that the timing of hard palate repair significantly affects the growth of the maxilla, earlier palate repair has a more adverse effect on the growth of the maxilla.

Following the most recent data collection visit in 2009, the authors reviewed cephalograms of a further 50 non-syndromic UCLP adult patients, all aged over 20 years of age. Cephalometric analysis to assess the effects of the timing of palatal repair on facial growth concurred with the earlier study (Figs. 10.13, 10.14, and 10.15). Patients who underwent hard palate surgery in infancy showed reduced maxillary length and protrusion when compared to patients who underwent surgery at a later age. Patients who undergo surgery according to accepted protocols in infancy exhibited more class III malocclusions.

10.4.2.2 Study Model Analysis

The authors have recently reviewed all patients treated in Sri Lanka who had records at age greater than 20 years. One hundred and ninety-eight patients were divided up according to the age of palatal repair and the GOSLON yardstick was used to assess the dental arch relationships. The scores clearly show that the earlier the repair, the more the detrimental affect it has on facial growth in the long term (Figs. 10.16 and 10.17).

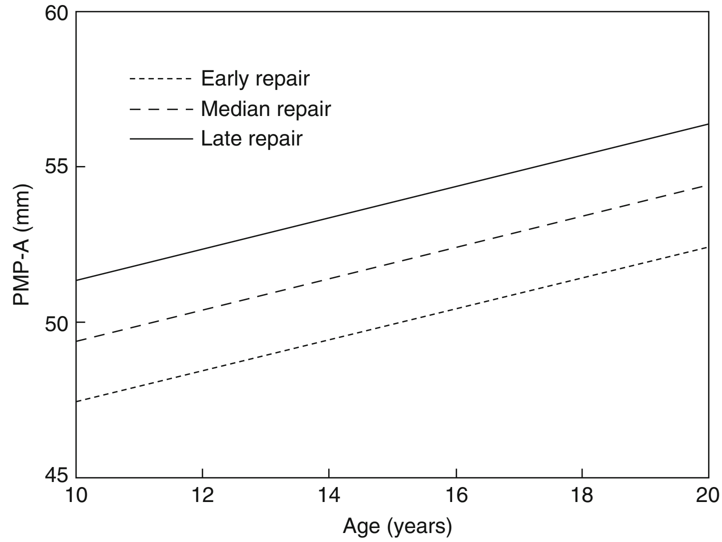


Fig. 10.10 Effect of timing of hard palate repair on palatal length (Liao et al. 2006)

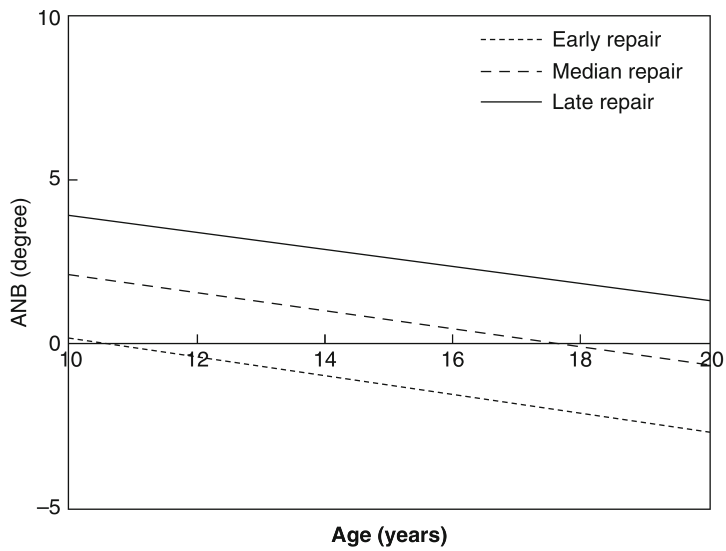


Fig. 10.11 Effect of timing of hard palate repair on maxillary-mandibular relationship (Liao et al. 2006)

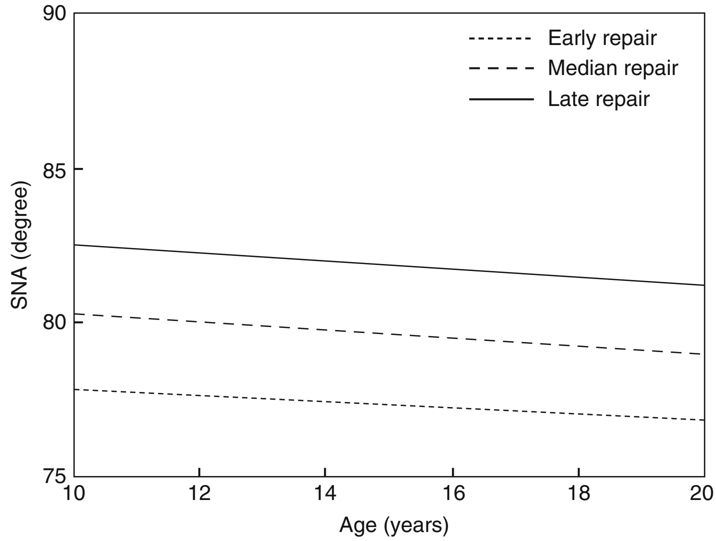


Fig. 10.12 Effect of timing of hard palate repair on maxillary protrusion (Liao et al. 2006)

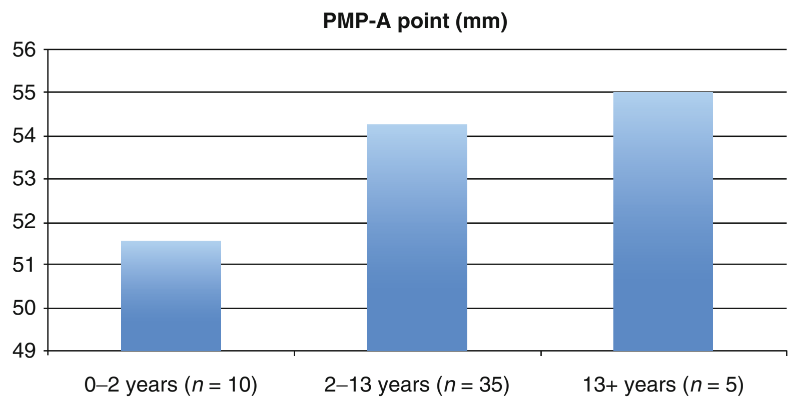


Fig. 10.13 Maxillary length related to age at primary surgery

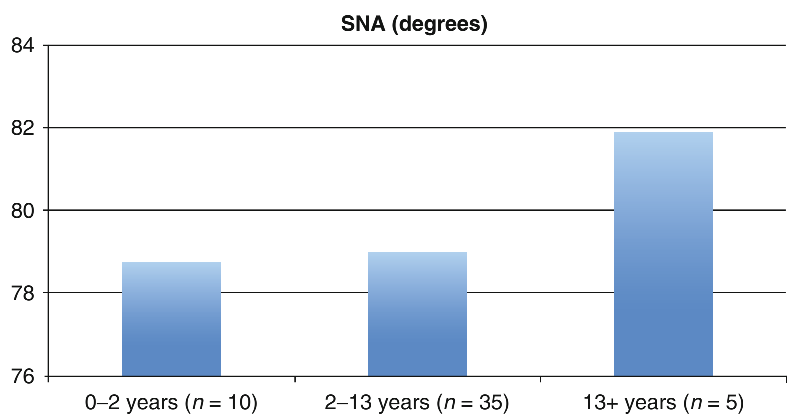


Fig. 10.14 Maxillary protrusion related to age at primary surgery

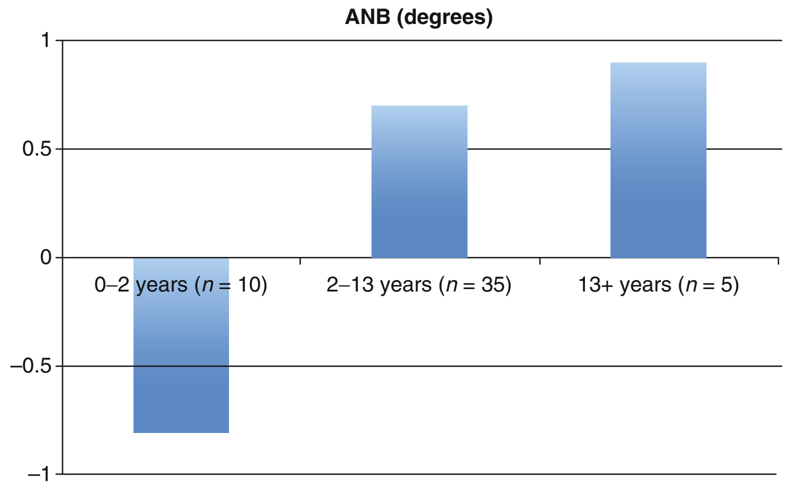


Fig. 10.15 Relative maxillary/mandibular protrusion related to age at primary surgery

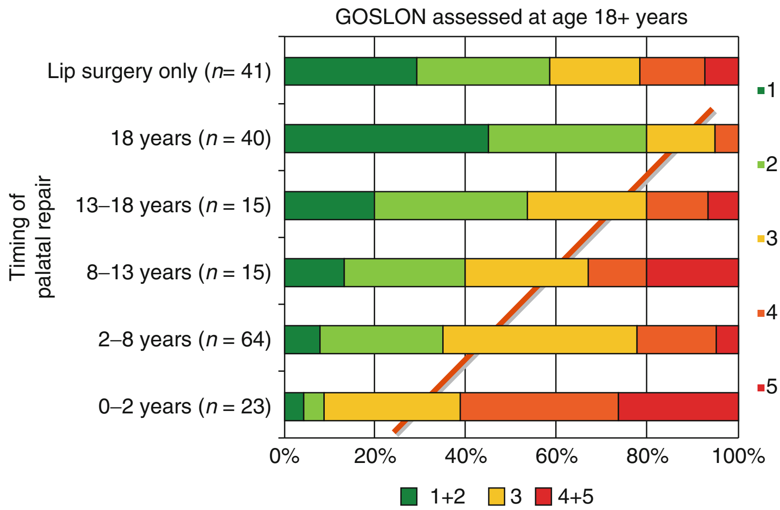


Fig. 10.16 Dental arch relationships and timing of palatal repair. The diagonal line demonstrates the progressively worsening effect with earlier surgery

Fig. 10.17 Adjust subject who had lip and palate repair in early infancy demonstrating maxillary retrusion

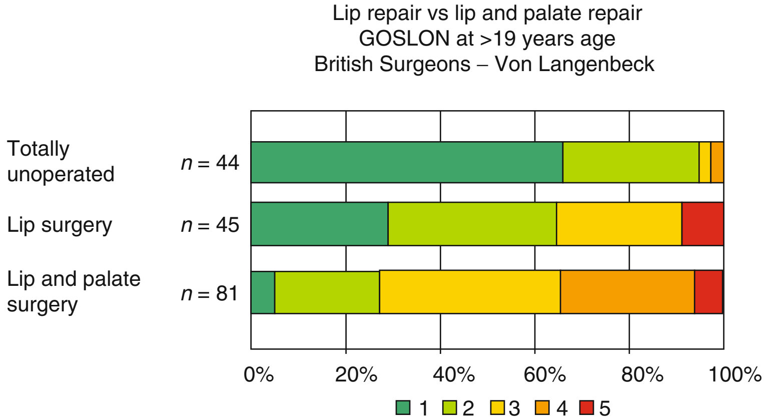


Fig. 10.18 GOSLON scores for adult patients operated by British Surgeons using the Von-Langenbeck procedure (Mars et al. 2005)

10.5 Type of Primary Surgery and Its Effect on Facial Growth

Studies from the SLCLPP data have clearly demonstrated the effects lip and palate surgery on facial growth. The data has been further analysed to assess any correlations on the type of surgery and its effects on long-term facial growth. The results have to be taken in context as subdivision of groups reduces numbers and the power of the study. However, the trends noted can form the basis for future randomised control trials.

10.5.1 Wardill-Kilner Versus Von Langenbeck Repair

There is no agreement on the best surgical approach. Both Pigott et al. (2002) and Johnston et al. (2004) reported increased proportions of poor or very poor GOSLON scores for a Veau-Wardill-Kilner repair group compared to a von Langenbeck group. The SLCLPP archive has patients who had had either the Wardill-Kilner or von Langenbeck procedures. The local Sri Lankan surgeons and some of the earlier visiting British surgeons favoured the Wardill-Kilner procedure. The Scandinavian surgeons and some of the later visiting British surgeons favoured the von Langenbeck procedure. The GOSLON yardstick used to assess outcome clearly shows that patients who undergo the Wardill-Kilner repair (Fig. 10.4) have poorer outcomes when compared to the von Langenbeck group (Fig. 10.18). These results do not take the skill of the surgeon into account, which clearly makes a difference.

10.5.2 Vomerine Flap

The use of a vomer flap has been another area of controversy. It was popularised by the Oslo team who have reported good long-term outcomes with their protocol (Semb 1991). Some groups believe that the use of a vomer flap is actually detrimental to future maxillary growth (Friede and Lilja 1994). Some surgeons within the SLCLPP routinely performed vomer flaps, whilst others did not. It has therefore been possible to tease out the effects of the use of vomerine flaps on dentoalveolar relationships in the long term.

The authors looked at adult UCLP patients who had only had a lip repair (31 patients) who were subdivided into two groups – lip with vomer flap and lip only. The GOSLON yardstick was used to assess outcomes depending on what age the lip surgery was carried out (Fig. 10.19). In both groups, surgery after 2 years of age did not have a marked effect on dentoalveolar relationships. In both groups, patients undergoing surgery in infancy had poorer GOSLON scores with more patients scoring 4 and 5 in the vomer flap group. This suggests that the vomer flap

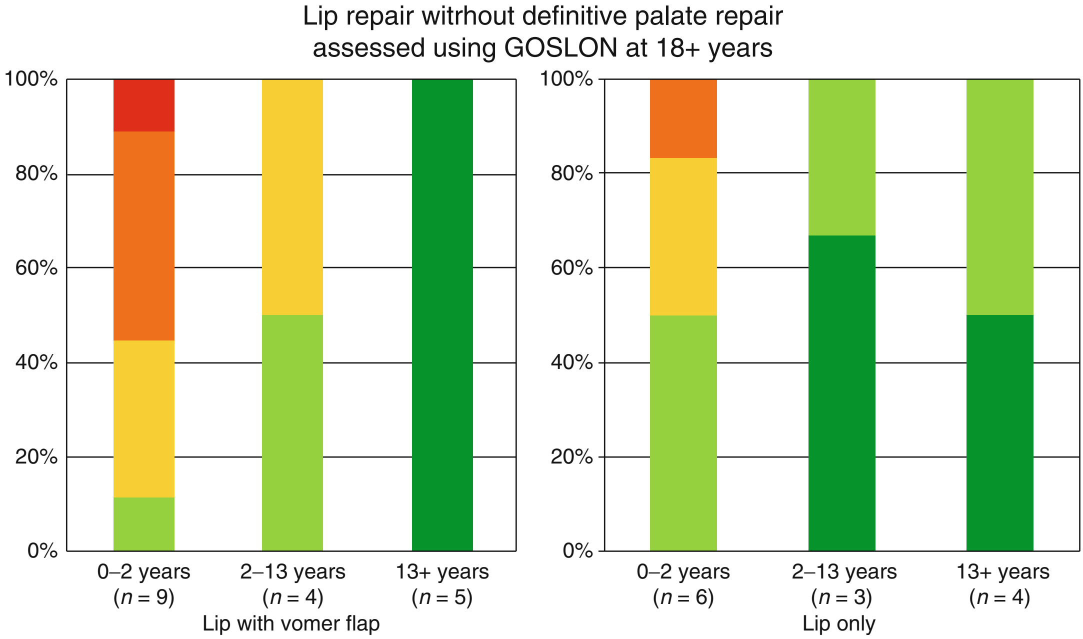


Fig. 10.19 GOSLON at age 18+ years for patients who had lip repair without definitive palate repair

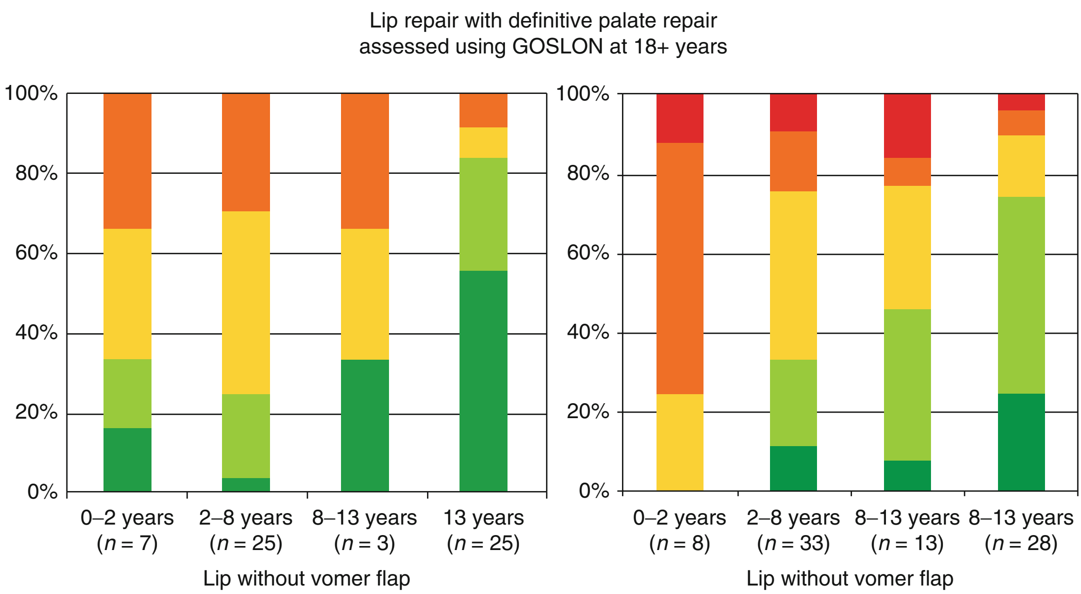


Fig. 10.20 GOSLON at age 18+ years for patients who had lip repair with definitive palate repair

may have some detrimental effect on the growth of the maxilla when assessed without the effects of hard palate repair.

Similarly, the authors analysed adult UCLP patients in the SLCLPP archive who had undergone both lip and palate surgery and subdivided these into two groups: lip with vomer flap (60 patients) and lip without vomer flap (82 patients). All patients underwent a von Langenbeck procedure to repair the palate. The GOSLON yardstick was used to assess outcomes depending on what age the lip surgery was carried out. The figure below (Fig. 10.20) clearly shows that patients who had a vomer flap repair did better and did not score 5 in any age group. In both groups, patients who underwent repair after the age of 2 did better than the younger patients in the long term. The use of a vomer flap provides 'extra' tissue to repair the hard palate and limits the use of extensive undermining of the soft tissues and relieving incisions. As discussed above, the palate repair has the most detrimental effect on long-term facial growth, and the use of a vomer flap in patients who undergo both lip and palate repair appears to be beneficial.

10.6 Factors Influencing Interpretation of Results from the Sri Lankan Cleft Lip and Palate Project

10.6.1 Malnutrition and Growth and Delayed Onset of Puberty

It should be recognised that the above studies are derived from subjects in the developing world. Although Sri Lanka is a relatively advanced developing country, there is nevertheless significant malnutrition and endemic infections, for example, malaria. The failure of infants with clefts to gain weight adequately has been documented by several authors (Avedian and Ruberg 1980; Ranalli and Mazaheri 1975).

Malnutrition is a well-recognised form of reversible growth hormone resistance, which can be normalised with nutritional supplements. A malnourished mother is likely to give birth to a baby with low birth weight, while children with protein-energy malnutrition do not grow as well as others according to a recent report (Fernando 1990). This kind of malnutrition is an underlying cause of almost one third of the deaths among children under 5 years in Sri Lanka. Malnutrition is still a serious problem in Sri Lanka (Rajapaksha and Siriwardena 2002). Food insecurity is one of the major reasons for malnutrition in that country according to the Department of Census and Statistics. Poor financial and physical access to food is responsible for the malnutrition and food insecurity. Drastic price increases of essential food commodities and stagnating or deteriorating incomes create poor financial access to food. The civil war from 1984 to 2010 in Sri Lanka has exacerbated the provision of essential food and has created financial problems.

A recent survey of 16,000 Sri Lankan children found that only one quarter were properly nourished (Popham 2002). More than one third were suffering from third-degree malnutrition, the level beyond which children exhibit distended stomachs and skinny frames. Supporting evidence from the National Peace Council indicated that only 4,863 children under 5 years out of a random sample of 16,767 were within normal nutritional limits; 6,371 children had third-degree malnutrition, 3,186 with second-degree malnutrition and 2,347 with first-degree malnutrition (National Peace Council of Sri Lanka 1998). According to this report, diseases such as malaria cause malnutrition first, which is still prevalent in Sri Lanka. Secondary causes of malnutrition are by worm infestations and third by a lack of food. Many of the subjects in this study were social outcasts, who dropped out of school. Females in particular were hidden away in their houses, and only one female in the un-operated population married. Children need a good emotional climate to thrive. The mechanism of the effects of emotional deprivation on growth is not well documented but is linked to reduced growth hormone secretion and its associated growth failure.

It has been recognised in the context of growth studies in general and facial growth studies in particular that many patients in the developing world have delayed onset of puberty (Mars 1993). Boys may not attain maturity until after 20 years of age and girls until after 18 years. This has important implications for all studies in developing countries and failure to address this issue can seriously confound the result of research. The large volume of longitudinal data has enabled this problem to be addressed (Liao and Mars 2006).

10.6.2 Speech Implications

Whilst facial growth in the un-operated subject presents without maxillary retrusion – unlike many operated patients – the speech outcomes for the same series of patients demonstrate almost unintelligible speech for the whole sample.

Research on the Sri Lankan Cleft Lip and Palate archive has demonstrated that surgery when delayed beyond eight years of age and even earlier results in permanent irremediable speech disorders (Sell and Grunwell 1990; Sell 1991).

This chapter is careful in not recommending the delay of hard palate repair. Previous studies have consistently demonstrated speech impairment associated with delayed hard palate repair (Bardach et al. 1984; Witzel et al. 1984; Noordhoff et al. 1987; Rohrich et al. 1996, Lohmander-Agerskov 1988).

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