Chapter 1

INTRODUCTION

1.1 Cleft Lip History and General Information

Evolution of cleft lip repair has been ongoing for many years and has been influenced by eminent surgeons such as Rose, Thompson, Tennison, Randall, LeMesurier, Trauner, Skoog, Millard and Mulliken to name but a few.

The reason for the development of various techniques stems from the advances relevant to function and aesthetics of the repair. A major advancement relating to the functional aspect of cleft lip repair relates to a better appreciation of the anatomy of both the cleft lip as well as the normal lip. This has been researched by Fara[1]and Nicolau[2]. The result of their research showed that the muscle fibers of the orbicularis oris muscle run vertically in the areas adjacent to the cleft lip. The realization of this aberrant anatomy has allowed the surgeon to modify his technique in an attempt to correct the muscle fiber direction to improve the function of the repaired lip. In addition, the latter surgeon pointed out the importance of

muscle repair in achieving a favourable outcome. This point has remained unchallenged and has become part of most repairs over the years. That is to say that all cleft lip repair techniques share a common ground in that they all attempt to restore the orbicularis oris sphincter continuity.

The approach to the cleft lip repair however, has not enjoyed the same acceptance due to the varying priorities of aesthetic factors placed by different surgeons. This has led to the myriad of procedures and modifications of the repair. The process began in the Renaissance with Ambrose Pare[3] who was responsible for one of the earliest attempts at cleft lip repair.

At about the turn of the 19th century, a straight line repair was proposed by Rose[4] and later Thompson[5], by freshening the edges and approximating the margins. This however created a short lip in the vertical dimension in most cases. The concept of flaps was introduced by the French surgeon Malgaigne[6], to provide additional length to the medial side of the cleft so as to better match that of the lateral side. Since then, many authors have developed differing flap techniques that have resulted in characteristic scars. For example, the LeMesurier[7] quadrangular flap, and the Tennison[8]–Randall[9] triangular flap. Both these techniques resulted in scars impinging on the lower

part of the philtral column. The most widely accepted technique is that described by Millard[10] in the 1950's. He altered the resultant scar, by placing a transverse back-cut in the upper, probably more concealed, area of the philtrum. This has the undesirable consequence of transgressing a natural anatomical boundary, namely, the philtral column. The resultant scar may thus be more noticeable. The Millard repair has traditionally been called the "rotation-advancement repair"

Another class of unilateral cleft lip repairs is the functional matrix repair. In this class, it is believed that the emphasis should be placed on reattaching tissues of the same embryological origin. Proponents of this theory include Veau[11] and Carstens[12] who suggest that operating on a cleft lip should merely be experimental embryology.

To date, no single repair technique has enjoyed universal acceptance.

Although there have been many different techniques described to repair a unilateral cleft lip, all aim to achieve a functional upper lip adhering to some basic aesthetic criteria, which are:

- Adequate vertical lip length on the cleft side (no peaking)

- No transgression of normal anatomical boundaries
- Appropriate Cupid's bow width
- Avoidance of vermilion "notching"(whistle tip).

The repair of the unilateral cleft lip has now reached a level where further advances are directed to a better aesthetic result as viewed by the patients and the surgeons. Over time, many well respected cleft lip surgeons have added their own modifications and described variations of a theme to improve the nuances of the unilateral cleft lip repair procedure. One such example is the improvement to the vermilion part of the repair that was described by Noordhoff[13]. Although minor refinements to the operation such as that described by Noordhoff have improved the repair of the unilateral cleft lip, the overall outcome is still anatomically challenged from an aesthetic point of view.

Further progress in the art of aesthetic unilateral cleft lip surgery requires a better understanding of the normal anthropometric measurements relating to the upper lip region. Farkas and colleagues[14] have previously performed extensive research on the upper lip dimensions in 1593 North American Caucasians. In his work, the Cupid's bow width (from peak to peak) and the width of the mouth (from left commissure to right

commissure) were measured which provided an average length of each of those measurements. He did not however correlate the width of the Cupid's bow with the width of the mouth in each individual person. Therefore he has not provided us with an average proportion between the Cupid's bow and the total horizontal lip length. Therefore, we are still unsure of the percentage that the Cupid's bow length contributes to the total horizontal lip length. It is obvious that a lip with a Cupid' bow length on the upper limit of normal on a lip whose total length is on the lower limit of normal would look unnatural. It is therefore easy to understand that the correlation between these two measurements (proportion) is more important than the measurements themselves.

Millard[15] has similarly performed some measurements on the Cupid's bow width and the total horizontal lip length which outlined certain differences between Caucasian and Negroid males and females. However he too did not make any correlation between the Cupid's bow length and the total horizontal lip length.

Lee[16] compared the growth on the cleft and non-cleft sides after rotation advancement repair (Millard technique). He showed that there is very little difference in the growth and that the vertical and horizontal dimensions were retained

according to the original repair. Further analysis of vertical lip length after Millard cleft lip repair has been studied by many authors such as Saunders[17], Randall[18], and Chowdri[19], with conflicting results. These studies mostly analyze the vertical lip length after cleft lip repair. Very little mention is made of the horizontal lip dimensions, more specifically, the relationship of Cupid's bow to the entire horizontal lip length. Although the vertical lip length is important in cleft lip repair, the different horizontal segments of the lip should also be in proportion for a natural looking lip.

Current surgical dogma states that Cupid's bow should be preserved in its entirety during cleft lip repair. The question therefore arises whether this results in a large cupid's bow due to stretching in the long term?
It has been shown by Cutting and Dayan[20] that the lateral segment of the lip stretches over time after cleft lip repair. Is it then not conceivable that the Cupid's bow also widens over time to proportions greater than normal?

A further concept is that highlighted by Mulliken[21] regarding the "fourth dimension". This pertains to the need for a thorough understanding of the changes that occur to the three dimensional form with growth of the child. More specifically,

at what age is Cupid's bow fully developed? This may pertain to the timing of secondary surgery if it is required. This concept has also been investigated by Xing et al[22] but they only considered the vertical height of the lip comparing the growth of the cleft side and the non-cleft side. They concluded that the cleft side grows normally after repair and that if you have a vertically symmetrical lip at one year of age, this should still be the case when adult life is achieved. By their own admission, this study is flawed by the very short follow up of one year and that all data was captured with the use of photographs. Similarly, Brusati et al[23] analyzed 20 cleft lip cases following a rotation-advancement repair (Millard technique) and emphasize the benefits of reconstructing the cleft lip as symmetrical to the opposite side as possible. Unfortunately, their results were also obtained from photographs and they only analyzed the vertical lip length and not the horizontal lip length.

Although there are many articles analyzing the results of cleft lip repairs in the literature, there is very little regarding the patient's impression of the repair. The surgeons have assessed their results according to different criteria which they feel is important and this also differs between different surgeons. This means of assessment is often biased and

difficult to interpret as most of the data is collected from post-operative pictures in many cases. The clinical decision as to whether a cleft lip requires secondary surgery may often differ between surgeons in the same patient. Trotman et al[24] have performed a study on the functional outcomes of cleft lip surgery and the need for secondary surgery to improve the aesthetic outcome. In part 1 of their study, they mention that the decision for lip revision is based on subjective clinical criteria where the clinicians may disagree. After analyzing this point, Trotman's findings suggested that the agreement among surgeons was poor and they supported the need for more objective measures to assess the need for revision surgery. This need for more objective assessment of the repaired unilateral cleft lip has resulted in complicated methods to assess facial asymmetry[25,26,27]. These methods, involve complicated machinery and computer programs which are very expensive and difficult to operate correctly. Therefore, these methods are not practical for analysis of the repaired cleft lip on a routine basis.

Of note, is the paucity of articles in the literature regarding the patient's impression of the repair of his or her cleft lip. It is not uncommon that the surgeon would identify a problem which could be repaired with secondary surgery but the patient

wishes for something different to be addressed. It is obviously important that the surgeons evaluate their results but it is just as important to understand what the patient is dissatisfied with as they may point out something completely different to what the surgeon has identified.

In summary therefore, further advances in the repair of a unilateral cleft lip can only proceed with the knowledge of certain factors. Firstly, it would be important to understand the normal anthropometric anatomy so as to try and recreate it. Secondly, it would be important to analyze the most commonly used technique for repairing a unilateral cleft lip (Millard technique) so as to identify its shortcomings. Thirdly, it would be helpful to understand what bothers the patients the most after having had a unilateral cleft lip repair.
If this information is known, attempts at improving the surgical repair of a unilateral cleft lip can proceed.

1.2 Overall Aims of Study

This study aims to describe a new technique for unilateral cleft lip repair and to substantiate its evolution by comparing it to the normal lip dimensions as well as the current technique of cleft lip repair (Millard technique). To do this, the following 4 points will be addressed separately.

1. To assess the normal anthropometric measurements regarding the horizontal lip dimensions.
    a. To assess normal horizontal lip dimensions according to different age categories in different people to serve as reference values.
    b. To assess the timing where the lip is fully developed.
    c. To assess Cupid's bow length in relation to horizontal lip length at different ages, thereby assessing dynamic changes with growth.

2. To evaluate the most commonly used current technique of unilateral cleft lip repair (Millard rotation advancement), both objectively and subjectively.

3. To compare the currently used technique of unilateral cleft lip repair to normal values indicating the anatomical drawbacks to the technique.

4. To describe a new technique for unilateral cleft lip repair which eliminates some of the unwanted drawbacks of the Millard technique.

Chapter 2

HORIZONTAL UPPER LIP DIMENSIONS AND DYNAMIC CHANGES OVER TIME

2.1 Aim

The aims of this part of the study are to:

1. Assess normal horizontal lip dimensions according to different age categories to serve as reference values for further studies.

2. Assess the timing where the lip is fully developed.

3. Assess Cupid's bow length in relation to horizontal lip length at different ages, thereby assessing dynamic changes with growth.

2.2 Method

A group of normal neonates, children, teenagers, and adults, were selected for study. Basic demographic data was collected including age and gender.

Any person with a syndromic condition, or previous surgery / injury to the face was excluded from the study.

Lip dimensions were obtained using a vernier caliper (Fig 2.1) with the patient at rest and neutral, i.e. no facial expression. The very young children were measured while sleeping to achieve accurate readings.

Figure 2.1 – Vernier Caliper

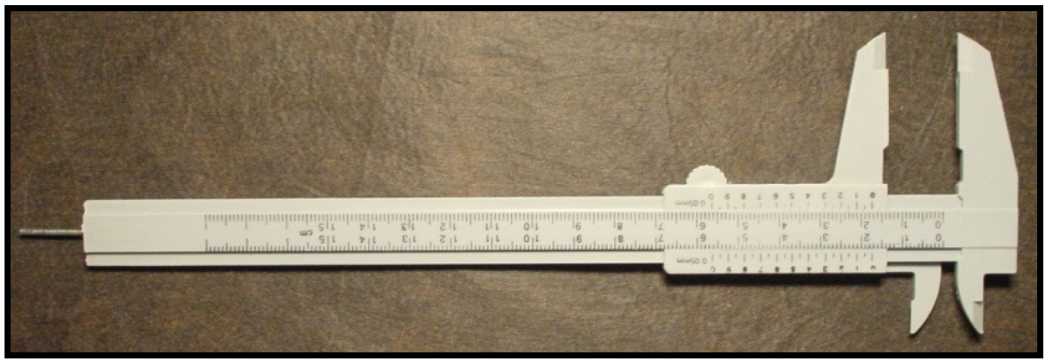


Figure 2.1 – Vernier Caliper
Vernier caliper used to measure lip dimensions

The lip dimensions measured were (Fig 2.2):

- Horizontal lip length (commissure to commissure)
- Cupid's bow width (peak to peak)
- Lateral lip segment length (commissure to ipsilateral Cupid's bow peak)

Figure 2.2 – Lip dimensions measured

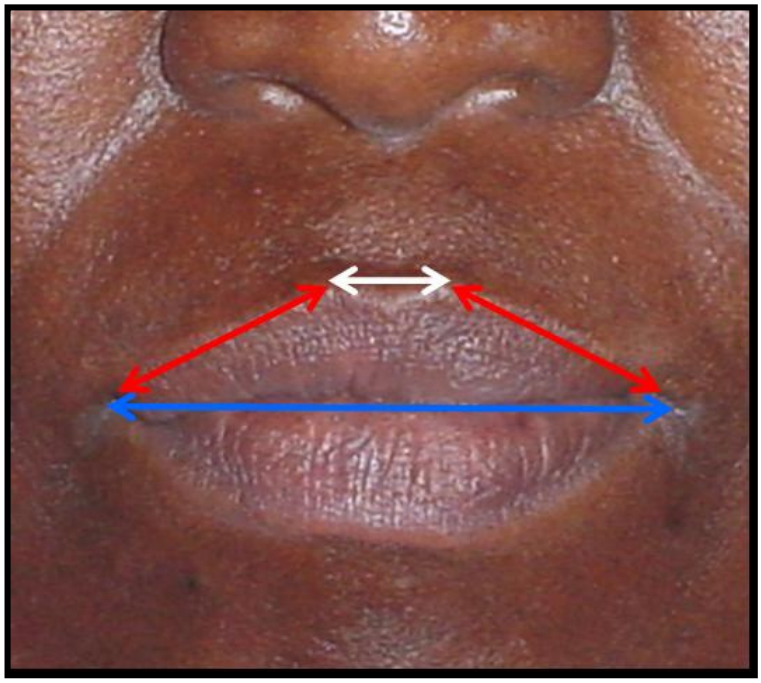


Figure 2.2 – Lip dimensions measured
- Lip dimensions measured are shown by the double sided arrows.
- The white arrow shows the Cupid's bow length from peak to peak.
- The red arrows show the horizontal lip length measured from the peak of Cupid's bow to the ipsilateral commissure.
- The blue arrow shows the horizontal lip length measured from commissure to commissure.

A total of 272 people were measured. The subjects were stratified according to age as well as gender to obtain average lengths of the different parameters measured for each age group (Table 2.1).

Table 2.1- Gender and Age-group Numbers

Age group number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Age group range	**Birth to 1month**	**1month to 1year**	**1year to 4years**	**4years to 8years**	**8 years to 12years**	**12years to 16years**	**16years to 20years**	**> 20years**
No of ♂	15	18	20	12	14	19	20	17
No of ♀	9	21	20	12	11	14	22	28
Total No	24	39	40	24	25	33	42	45

The data was analyzed and plotted onto graphs relating age to different parameters.

Parameters assessed included:

- The width of Cupid’s bow (Cupid’s bow peak to Cupid’s bow peak) in relation to age.
- The length of the lateral lip segments (Cupid’s bow peak to ipsilateral commissure) in relation to age.
- The width of the mouth (commissure to commissure) in relation to age
- The ratio of Cupid’s bow width to total lip length (commissure to commissure) was calculated for each subject.
- The male lip dimensions versus female lip dimensions at corresponding ages were compared.

2.3 Results

The results of the 272 subjects is tabulated in appendix A which reflects the age and the actual measurements (in millimeters) for each individual subject.

The data in Appendix A was analyzed further and the results were tabulated in a more manageable form (Table 2.2). Table 2.2 indicates the number of males and females in each age category. Separate averages for males and females were calculated for each parameter analyzed. In addition, an average for the entire age group combining males and females was calculated.

The following abbreviations were used for Table 2.2.

C-C : Commissure to Commissure measurement (horizontal lip length).

P-P : Cupid's bow peak to Cupid's bow peak measurement (Cupid's bow width).

L: C-P : Commissure to Cupid's bow peak measurement on the left side (left lateral lip segment length).

R: C-P : Commissure to Cupid's bow peak measurement on the right side (right lateral lip segment length).

P-P/C-C : Ratio of the length of Cupid's bow measured from peak to peak on the one hand and the total lip length measured from commissure to commissure on the other.

Table 2.2 – Average Lip Dimensions in each Age Category

Range : 0 – 1 month (Age Group 1)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
9	**Female Average**	**25.61**	**4.89**	**12.94**	**13.11**	**19.08**
15	**Male Average**	**25.93**	**5.10**	**12.90**	**12.87**	**19.68**
24	**Combined Average**	**25.81**	**5.02**	**12.92**	**12.96**	**19.45**
Range: 1 month – 1 year (Age Group 2)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
21	**Female Average**	**29.57**	**6.17**	**14.64**	**14.64**	**20.87**
18	**Male Average**	**31.97**	**6.78**	**15.61**	**15.61**	**21.27**
39	**Combined Average**	**30.68**	**6.45**	**15.09**	**15.09**	**21.05**
Range: 1 – 4 years (Age Group 3)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
20	**Female Average**	**34.00**	**7.42**	**16.81**	**16.81**	**21.77**
20	**Male Average**	**35.78**	**8.23**	**17.33**	**17.33**	**22.98**
40	**Combined Average**	**34.93**	**7.84**	**17.08**	**17.08**	**22.40**

Range: 4 – 8 years (Age Group 4)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
12	**Female Average**	**37.21**	**8.58**	**18.92**	**19.08**	**23.07**
12	**Male Average**	**37.83**	**8.79**	**17.38**	**17.33**	**23.22**
24	**Combined Average**	**37.52**	**8.69**	**18.15**	**18.21**	**23.14**
Range: 8 – 12 years (Age Group 5)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
11	**Female Average**	**39.27**	**9.86**	**17.82**	**18.00**	**25.17**
14	**Male Average**	**42.36**	**10.32**	**19.29**	**19.25**	**24.38**
25	**Combined Average**	**41.00**	**10.12**	**18.64**	**18.70**	**24.73**
Range: 12 – 16 years (Age Group 6)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
14	**Female Average**	**46.11**	**10.71**	**21.46**	**21.32**	**23.28**
19	**Male Average**	**47.18**	**10.82**	**22.32**	**22.45**	**22.93**
33	**Combined Average**	**46.73**	**10.77**	**21.95**	**21.97**	**23.08**

Range: 16 – 20 years (Age Group 7)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
22	**Female Average**	**50.18**	**10.64**	**22.55**	**22.57**	**21.18**
20	**Male Average**	**51.45**	**11.58**	**23.10**	**23.20**	**22.47**
42	**Combined Average**	**50.79**	**11.08**	**22.81**	**22.87**	**21.80**
Range: > 20 years (Age Group 8)						
No	**Gender**	**C – C**	**P – P**	**L: C–P**	**R: C–P**	**P–P/C–C**
28	**Female Average**	**49.02**	**10.14**	**22.70**	**22.63**	**20.70**
17	**Male Average**	**51.29**	**11.41**	**22.53**	**22.47**	**22.26**
45	**Combined Average**	**49.88**	**10.62**	**22.63**	**22.57**	**21.29**

The above values can be found with standard deviations as calculated statistically using statistica in Appendix B (Table B1).

In neonates, the average of the C–C length was 25.81mm, and the average length of the Cupid's bow was 5.02mm. In this age group, the Cupid's bow length was found to be 19.45% of the total lip length on average. No obvious difference was found between males and females.

Within the first year of life, the C-C length increased to 30.68mm, and the Cupid's Bow width increased to 6.45mm. The proportion of the total lip length occupied by the Cupids Bow increased to 21.05%.

Over the next 7 years, there was a steady increase in the lip dimensions resulting in an average lip length of 37.52mm, and an average Cupid's Bow width of 8.69mm. Over this period, the proportion of the Cupid's Bow to the total lip length increased to 23.14%.

There was a greater relative change in the lip dimensions in the 8 – 12 year category. In addition, the Cupid's Bow occupied the greatest proportion (24.73%) of the total lip length in comparison to any other age group.

Beyond age 12, the lateral lip segments increased in length, with very little increase in length of the Cupid's Bow. This resulted in a decrease of the proportion of the Cupid's Bow to the total lip length ratio (21.29%).

2.4 Discussion

2.4.1 Width of Cupid's bow in relation to age (Figure 2.3)

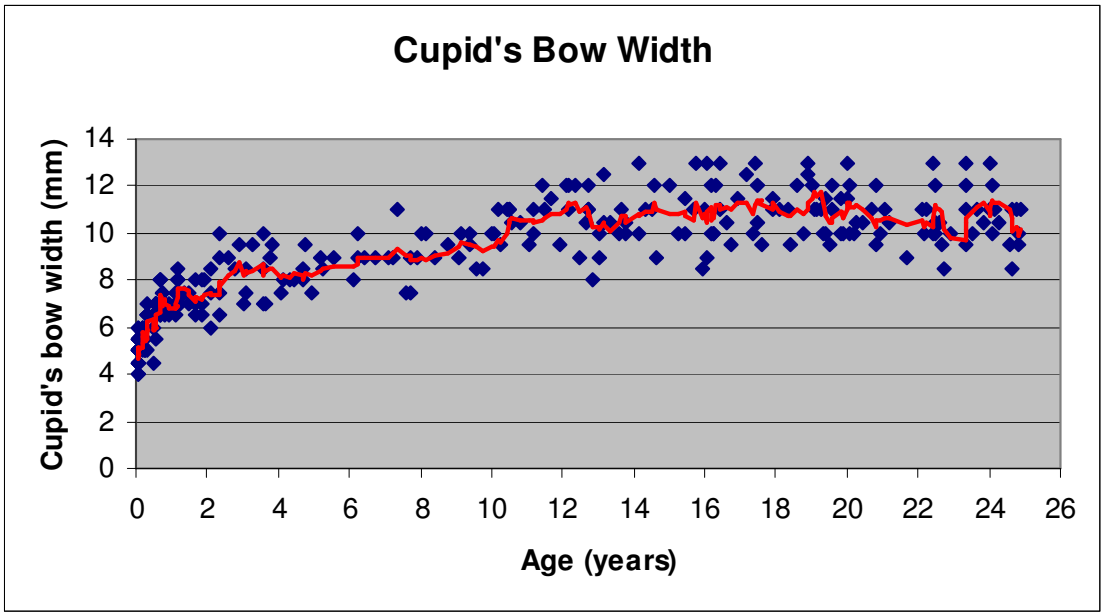
The width of Cupid's bow ranged between 4mm to 6mm at birth, and 8.5mm to 13mm in adulthood. These findings are not unlike those found by Farkas in North American Caucasians, where the mean width of Cupid's bow was 6.7mm at 1 year of age and 10.9mm in adulthood[2].

Not surprisingly, there was an increase in width of the Cupid's bow with increasing age, indicating its growth. However, two growth spurts were noted in this upward trend. The first growth spurt occurred between 0 and 48 months (but mostly in the first 24 months). At 4 years of age, the Cupid's bow was roughly 80% of adult size. After the first growth spurt, the Cupid's bow increased in size slowly but steadily until 10 years of age. Thereafter, the second growth spurt occurred where the Cupid's bow increased in size more rapidly. This rapid growth continued until 12 years of life after which no further increase in size was noted. This would imply that the Cupid's bow reaches adult size by age 12 years, and does not grow any further. This has bearing on the timing of secondary cleft lip surgery if it is required. It would be wise to wait until the growth of the

Cupid's bow is complete before any secondary surgery is attempted.

The Cupid's bow width in relation to age is statistically analyzed and explained in Appendix B, Table B2 and Graph B1.

Figure 2.3 – Cupid's Bow Width



2.4.2 Size of the lateral lip segments in relation to age (Figure 2.4)

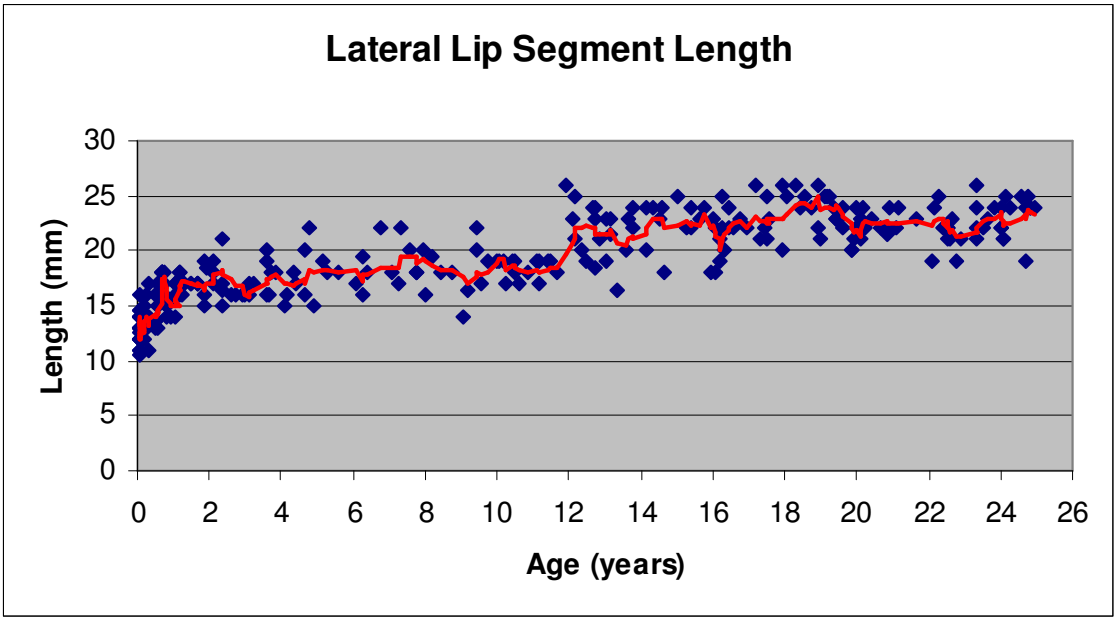
The lateral lip segments (measured from peak of Cupid's bow to ipsilateral commissure) also showed two growth spurts. The first growth spurt occurred between 0 and 12 months of age. Thereafter there was slow growth until 12 years of age after

which the second growth spurt occurred. This continued until 15 years of age after which the size of the lateral segments remained relatively static up to adulthood.

Although the lateral lip segments also had two growth spurts, the first was not as long lasting as that of the Cupid's bow, and the second occurred much later than the second growth spurt of the Cupid's bow. This would obviously affect the ratio between the Cupid's bow to the full horizontal length of the lip at the different ages during growth.

The Lateral lip segment length in relation to age is statistically analyzed and explained in Appendix B where the left and right lateral segments have been analyzed separately (left lateral segment – Table B3 and Graph B1; right lateral segment – Table B4 and Graph B3)

Figure 2.4 – Lateral Lip Segment Length

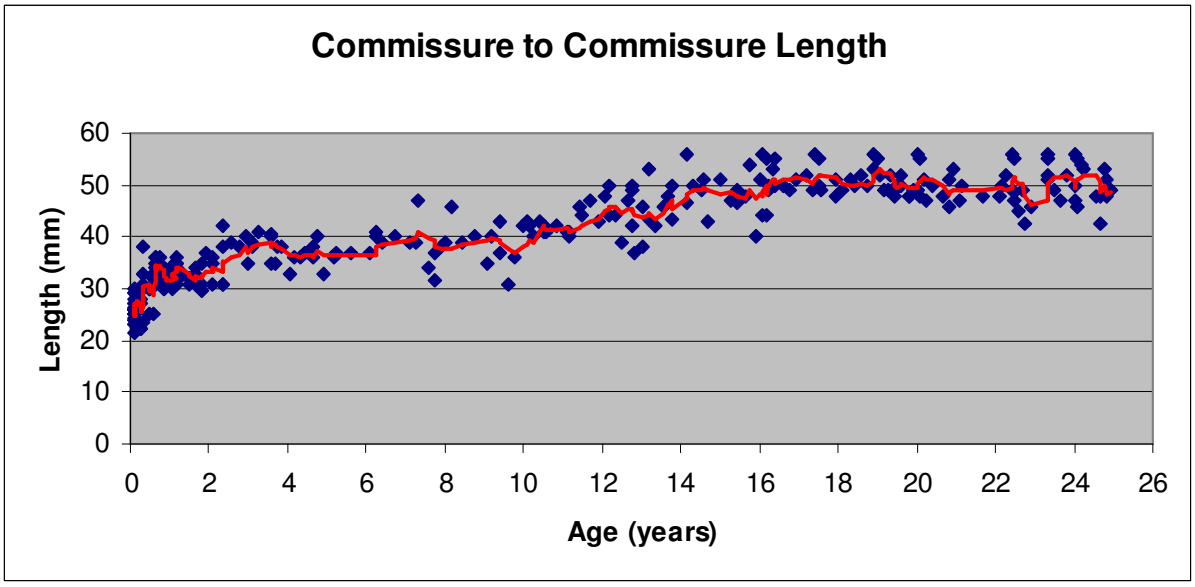


2.4.3 **Width of the mouth in relation to age** (Figure 2.5)

The width of the lip as measured from the commissure to the opposite commissure is influenced by the changes that occur to the Cupid's bow as well as the changes that occur to the lateral lip segments.

With age, the lip width increased until about 15 years of age, at which time it was adult size and showed no further growth. The growth spurts of the Cupid's bow and the lateral lip segments can be seen on the graph.

Figure 2.5 – Commissure to Commissure Length



2.4.4 Cupid's bow to lip length ratio in relation to age (Figure 2.6)

As shown in Figure 2.3 above, the size of Cupid's bow reaches that of an adult at ± 12 years of age. In contrast, the lateral segments continue to grow for a period longer and reach adult size at 15 years of age. This is most likely related to the embryologic derivation of these separate parts of the lip, where the philtrum and Cupid's bow is derived from the frontonasal process and the lateral aspects of the lip are derived from the 1st branchial arch.

Although Farkas has given absolute values for the normal range of both the philtrum and the commissure to commissure length, they should not be divorced because it is their combination that will decide the aesthetic appearance of the upper lip. For example, a Cupid's bow width at the upper limit of normal in a lip whose commissure to commissure distance is at the lower limit of normal will still look unnatural. It is therefore inadequate to measure the Cupid's bow and the commissure to commissure lengths indipendantly of each other and assess whether they fall within normal limits as it is the relationship that will give the appearance of the lip. Normal reference values for the ratio between the Cupid's bow width

and the width of the mouth would therefore give a better guide to the normal appearing upper lip.

It is clearly shown in this study, that the Cupid's bow has been shown to increase in size with increase in age, but there are two growth spurts. The first is in the first year of life and the second in between ages 10 years and 12 years. At birth, the Cupid's bow to lip length ratio is roughly 20%. This means that one fifth of the entire lip length is taken up by the Cupid's bow. This increases slowly up to age 10 years when the Cupid's bow grows more rapidly than the lateral lip segments and results in a ratio of about 25%. In other words, the Cupid's bow occupies one quarter of the entire lip length at this time. Interestingly, this ratio starts to decrease after 12 years of age as the lateral lip segments start to grow more rapidly than the Cupid's bow. The ratio decreases to about 22% in adulthood.

In summary then, it is safe to say that the Cupid's bow occupies about one fifth to one quarter of the entire lip length in the normal population at any one given time.

Franz and Sokol[28] have previously measured the ratio in question relating it to bilateral cleft lip repair in 1972. The average ratio obtained was 1:3.75 (Cupid's bow : commissure to

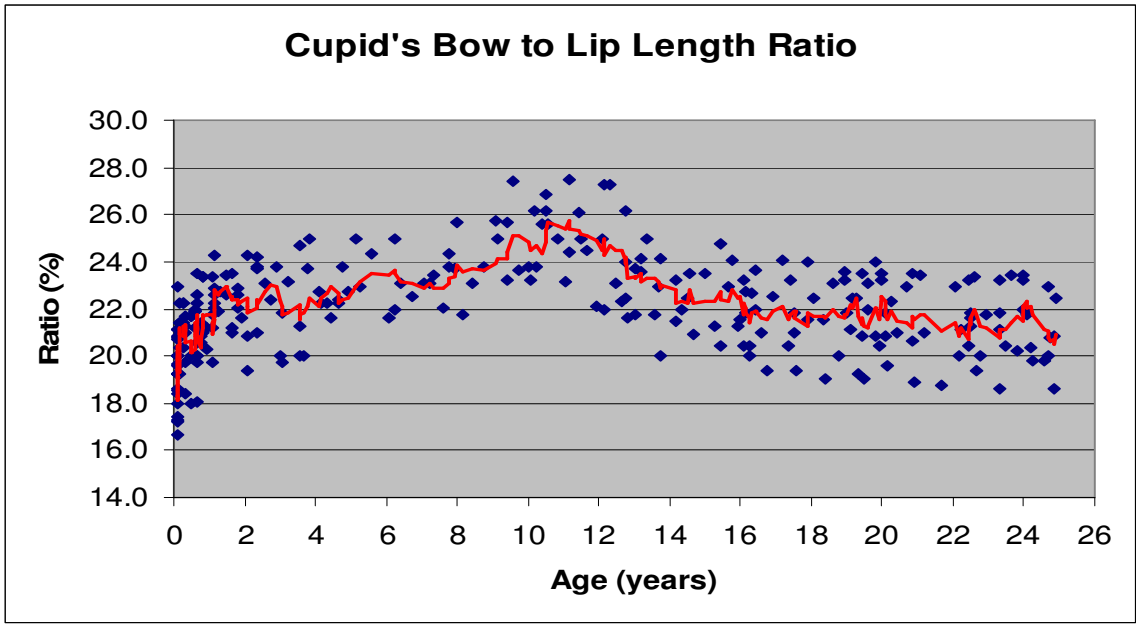
commissure). This was only performed in children less than 4 months of age and did not take into consideration the growth of the different lip elements over time. It also does not take into consideration any stretching that may occur after repair of the bilateral cleft lip. This study would be most useful for the repair of bilateral cleft lips using an Abbe flap.

Furthermore, it is clear from graph 4 that the ratio between the Cupid's bow width and the commissure to commissure distance, changes during the growth of the child. This is because the growth spurts related to the Cupid's bow and the lateral segments of the lip are different in time and magnitude. This must be taken into consideration during lip surgery as the growth pattern of the different segments of the lip (as shown above) is unlikely to change after the surgery. This hypothesis is relevant in cleft lip surgery. If one believes that the Cupid's bow will stretch slightly after cleft lip surgery (as would occur with the lateral aspects of any wound closed over a defect), then one would have to make the Cupid's bow slightly smaller to remain within the normal limits after stretching has occurred. This would also be supported by the working fourth dimensional hypothesis mentioned by Mulliken[21,31], where it is suggested that features that are programmed for rapid growth (as is the Cupid's bow) should be

crafted on a smaller scale than normal. In addition, Cutting[20] has shown that the lateral segment of the lip does lengthen over time due to the closure of the lip and it stands to reason that the medial segment, in this case the Cupid's bow, would also lengthen to a degree. If it is kept in its entirety from the beginning of a cleft lip operation, then it is at risk of stretching to beyond the normal size resulting in an abnormal proportion between the Cupid's bow and the entire lip length.

The ratio between the Cupid's bow and the entire lip length has been analyzed statistically in Appendix B, Table B5 and Graph B4.

Figure 2.6 – Cupid's Bow to Lip Length Ratio



2.4.5 **Males versus Females** (Figure 2.7, 2.8, 2.9, 2.10)

On comparing males and females, it was noted that both had very similar growth patterns. The females however, did not have as wide a Cupid's bow as did the males after development was complete. In addition, the ratio between the Cupid's bow to total lip length was smaller in females after development was complete. This would signify that the Cupids bow is narrower in females relative to the entire lip length.

The following graphs represent the comparison between males and females where the males are represented by the blue dots and the females by the pink dots.

Figure 2.7 – Males vs Females for Cupid's Bow Length

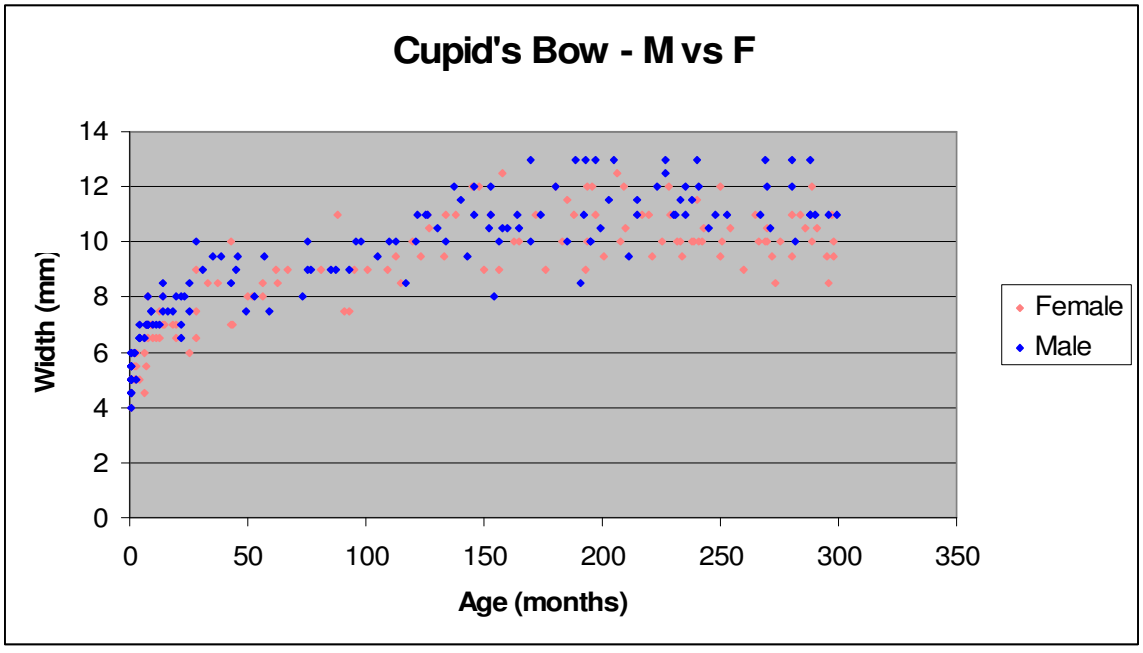


Figure 2.8 – Males vs Females for Cupid's Bow to Lip Length Ratio

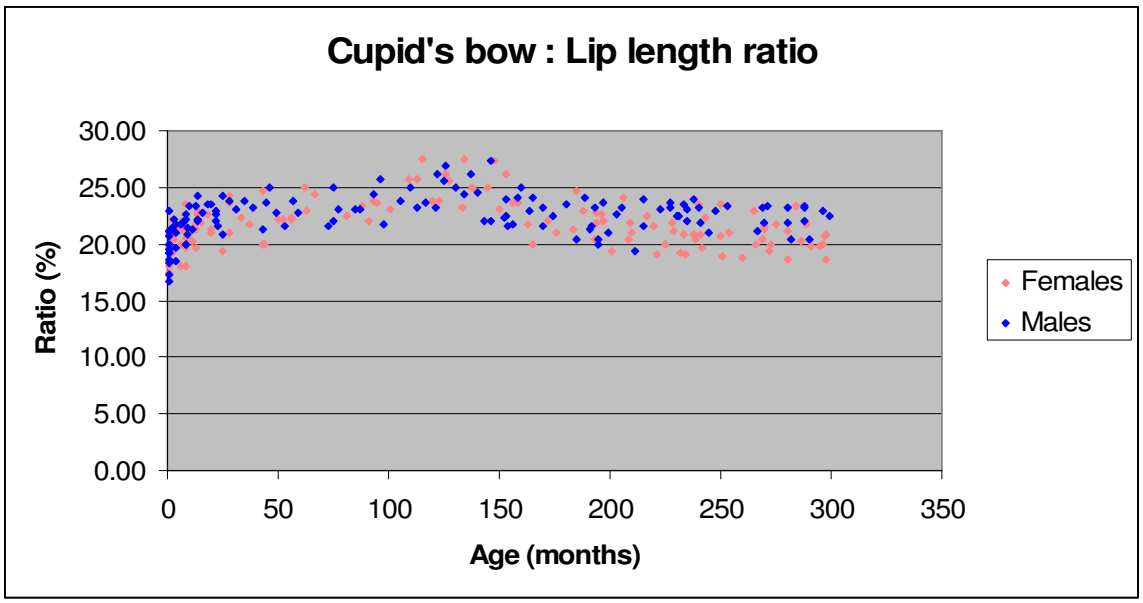


Figure 2.9 – Males vs Females for Commissure to Commissure Length

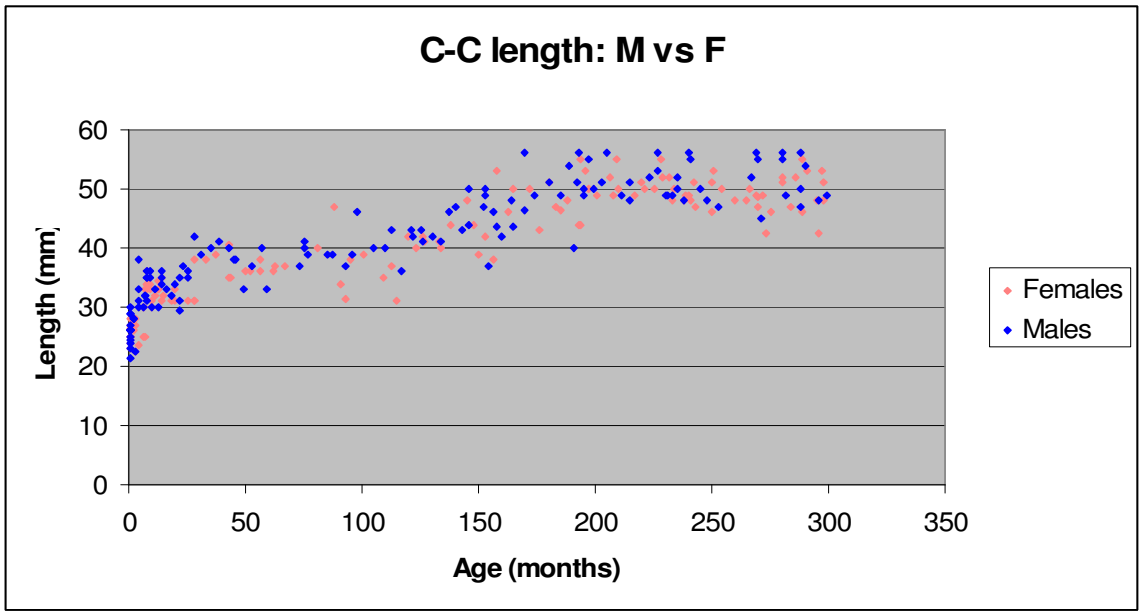
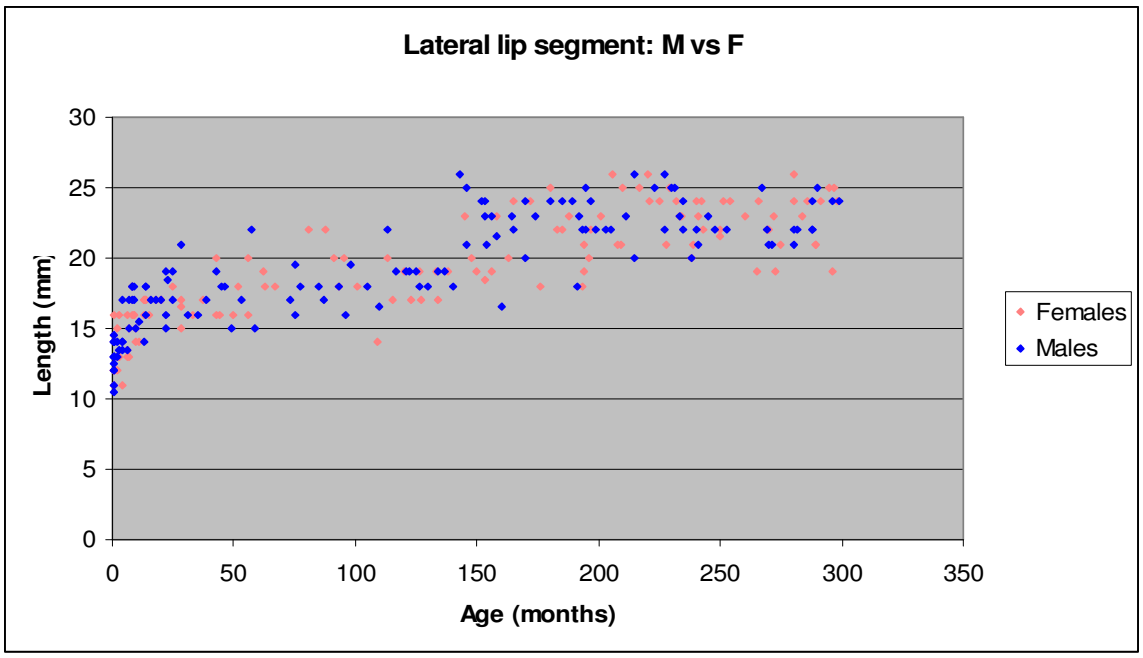


Figure 2.10 – Males vs Females for Lateral Lip Segment Length



2.5 Conclusion

Similar to the difficulties encountered by theoretical physicists who have been trying to unify divergent paradigms of their knowledge into a single "unified theory", this study does not resolve many issues regarding lip surgery. I believe however, that it offers the following:

- A better understanding of lip growth over time ("fourth dimension"). More specifically, identifying periods of accelerated growth of the different horizontal lip elements where any secondary surgery could be delayed.
- A better understanding of the numerical values of the horizontal lip elements and how they relate to each other at any given time in the patient's life. This may assist with the planning of excisional or restorative surgery.
- It raises the question of whether it is anatomically feasible to preserve the entire Cupid's bow during cleft lip repair. As with any approximation of wound edges across a defect, there will be some form of stretching at the wound edges. This has been shown to be true for the lateral lip segments by Dayan and Cutting. If this is true also for the medial part of the lip repair, then the Cupid's bow would stretch out to larger than normal size if it was preserved in its entirety. The enlarged Cupid's

bow would then still go through the growth spurts as shown above and remain proportionally large in comparison to the rest of the horizontal lip length.

In addition, the pattern of growth observed over the years, could serve as a standardized template against which to analyze the outcomes of particular surgical lip procedures, specifically cleft lip surgery. This could perhaps identify certain drawbacks of the many procedures described for cleft lip repair and highlight the areas requiring change. This however would only be feasible if long-term outcomes were analyzed according to the above parameters and plotted on the graphs above.

Logically, it stands to reason that a child whose horizontal lip dimensions fall inside two standard deviations of the mean, is likely to develop proportionally normal horizontal lip dimensions with growth. Although not proven, this hypothesis is based on the concept of normal height, weight and head circumference growth charts for children.

In summary:

- It is important to assess the absolute values of the lip dimensions, but also to assess the different horizontal lip dimensions in relation to each other (P–P : C–C ratio)
- Hypothesis – When performing lip surgery, it would be feasible to attempt to gain a result which places the ratio between the Cupid's bow and the commissure to commissure length within the normal limits as shown in the graph above.
- The possibility of stretching of the medial segment (as does the lateral segment) of repaired unilateral cleft lips must be taken into consideration.
- Secondary surgery to the lip should be performed after lip development is complete and the normal ratios of the horizontal lip elements should be restored if possible.
- Outcome studies should be performed and related to the growth chart for lip development as the ratio between the Cupid's bow width and the horizontal lip width changes with the development of the child.

Chapter 3

A LONG TERM SUBJECTIVE AND OBJECTIVE ASSESSMENT OF UNILATERAL CLEFT LIP REPAIRS USING THE MILLARD TECHNIQUE WITHOUT REVISIONAL SURGERY

3.1 Aim

The aim of unilateral cleft lip repair is to achieve a functional and aesthetically acceptable upper lip.

Surgical procedures described to do this are protean, but many do not fulfill the basic aesthetic criteria, which are:

- Adequate lip length on the cleft side (no “peaking”)
- No transgression of normal anatomical boundaries
- Appropriate Cupid’s bow width
- Avoidance of vermilion “notching”

Millard described his revolutionary rotation advancement technique in the 1950's in order to achieve these goals.
The following series assesses the long term results from a subjective and objective point of view in a group of 20 patients who only had the initial repair, as described by Millard, without further revisional surgery.

In other words, all the patients who were included in this part of the study had previously had a Millard rotation advancement unilateral cleft lip repair at about 3 months of age. They did not have any further surgery after their initial repair so the results that were obtained are reflective of the initial repair technique. At this time, the Millard technique to repair a unilateral cleft lip is the most commonly utilized technique world-wide.

The aim is to assess the most commonly used technique for the repair of unilateral cleft lip repairs both objectively and subjectively.

3.2 Materials and Methods

Twenty patients (ages ranged from 11 to 22 years) with a unilateral cleft lip who had a Millard rotation advancement repair were selected. The repair was undertaken by a single surgeon experienced in this type of surgery.

The patients either had a complete or incomplete unilateral cleft lip. Surgery was undertaken at approximately 3 months of age and no secondary procedures were performed thereafter. The analysis related essentially to the residual scar.

Patients were assessed subjectively and objectively.

For subjective evaluation, the patient received a questionnaire to complete (Table 3.1).

Objective assessment was done by means of clinical evaluation and measurements using the criteria shown in the objective evaluation form (Table 3.2)[29].

A control group (n = 20) of normal patients, of similar age, male to female ratio and of similar racial distribution was selected for comparison of the Cupid's bow. Identical measurements were taken in this group for comparison between the cleft group and normal patients.

Table 3.1 – Patient Questionnaire

Patient Questionnaire

Please answer the following questions and tick the appropriate boxes below. The aim is to identify your satisfaction with your cleft lip repair. In particular, we are assessing the scar and wish to ascertain exactly what bothers you most.

1	Very satisfied (Very happy)
2	Doesn't bother me much (Happy)
3	Could have been better (Okay)
4	Not satisfied at all (Unhappy)

1. Are you satisfied with the colour of the scar?

1		2		3		4	

2. Are you satisfied with the texture (smoothness) of the scar?

1		2		3		4	

3. Are you satisfied with the width of the scar?

1		2		3		4	

4. Are you satisfied with the thickness (amount of bulging above the skin) of the scar?

1		2		3		4	

5. Are you satisfied with the shape (lines, angles etc) of the scar?

1		2		3		4	

6. Are you satisfied with the Cupid's bow?

1		2		3		4	

7. What part of the scar bothers you the most? (Figure 3.1)

Upper part close to nose	
Middle part	
Lower part close to lip	

Table 3.2 – Objective Scar Evaluation

Objective Evaluation

Colour of Scar

Same as surrounding skin	
Lighter than surrounding skin	
Darker than surrounding skin	

Width of Scar
(measured with calipers; mm)

Upper part close to nose (1mm below columella)	
Lower part close to white roll (1mm above vermilion)	

Surface Texture of Scar

Generally smooth throughout	
Generally irregular throughout	
Upper part irregular	
Lower part irregular	

Thickness of Scar

Level with surrounding skin	
Depressed	
Elevated	

Scar Transgression of Anatomical Boundaries

Yes	
No	

If yes, where? _____

"Peaking" or "Notching" of Vermilion (Figure 3.2)

Yes	
No	

Lip Length (cleft side vs non-cleft side - measured from peak of Cupid's bow to base of columella) (Figure 3.3)

Cleft side	
Non-cleft side	

Cupid's Bow Measurement (peak to peak; mm)

Upper Lip Measurement (commissure to commissure; mm)

Figure 3.1 – Upper, Middle and Lower part of scar Shown

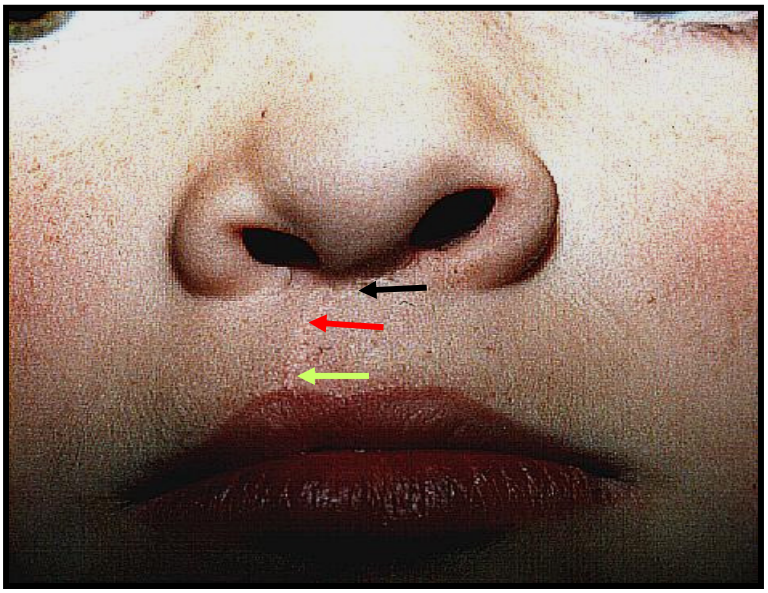


Figure 3.1
Arrows showing upper (black arrow), middle (red arrow) and lower (yellow arrow) part of scar.

Figure 3.2 – "Peaking" and "Notching" of the Vermilion

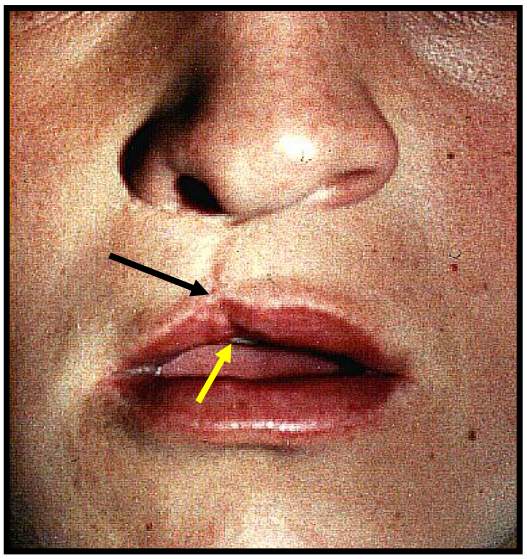


Figure 3.2 - "Peaking" and "notching" of the vermilion.
Peaking - Upper black arrow.
Notching - Lower yellow arrow.

Figure 3.3 – Cleft Lip Group Measurements Taken

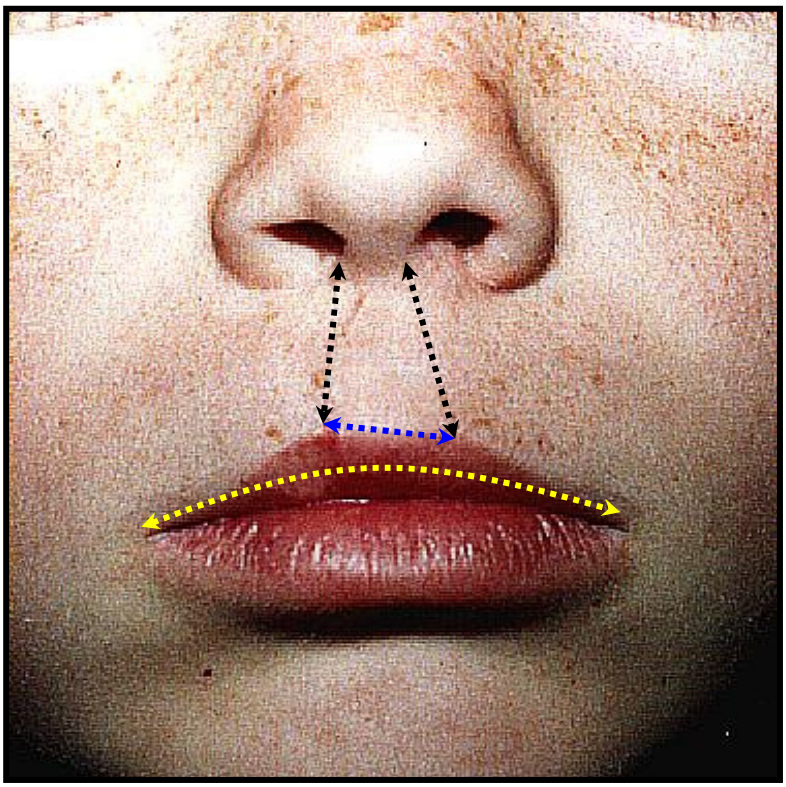


Figure 3.3 Cleft Lip Group Measurements taken

Diagram showing measurements taken on each patient in the cleft lip group. Similar measurements were taken in the non-cleft group of patients.

- Commissure to Commissure length – Yellow dotted line
- Cupid's Bow Width – Blue dotted line
- Philtral Column Length (left and right) – Black dotted line

3.3 Results

3.3.1 SUBJECTIVE EVALUATION

When analyzing the colour, texture, width and thickness of the scar, it was found that the majority of patients were very happy or happy. The percentages for each group are shown in table 3.3. Few patients were very unhappy with these parameters (Table 3.3, Figure 3.4).

Table 3.3 – Subjective Results for Each Category

	Colour	**Texture**	**Width**	**Thickness**
Very happy	6 (30%)	5(25%)	8(40%)	5(25%)
Happy	9 (45%)	10(50%)	7(35%)	10(50%)
Okay	4(20%)	4(20%)	3(15%)	2(10%)
Unhappy	1(5%)	1(5%)	2(10%)	3(15%)

Figure 3.4 – Subjective Evaluation of Scar

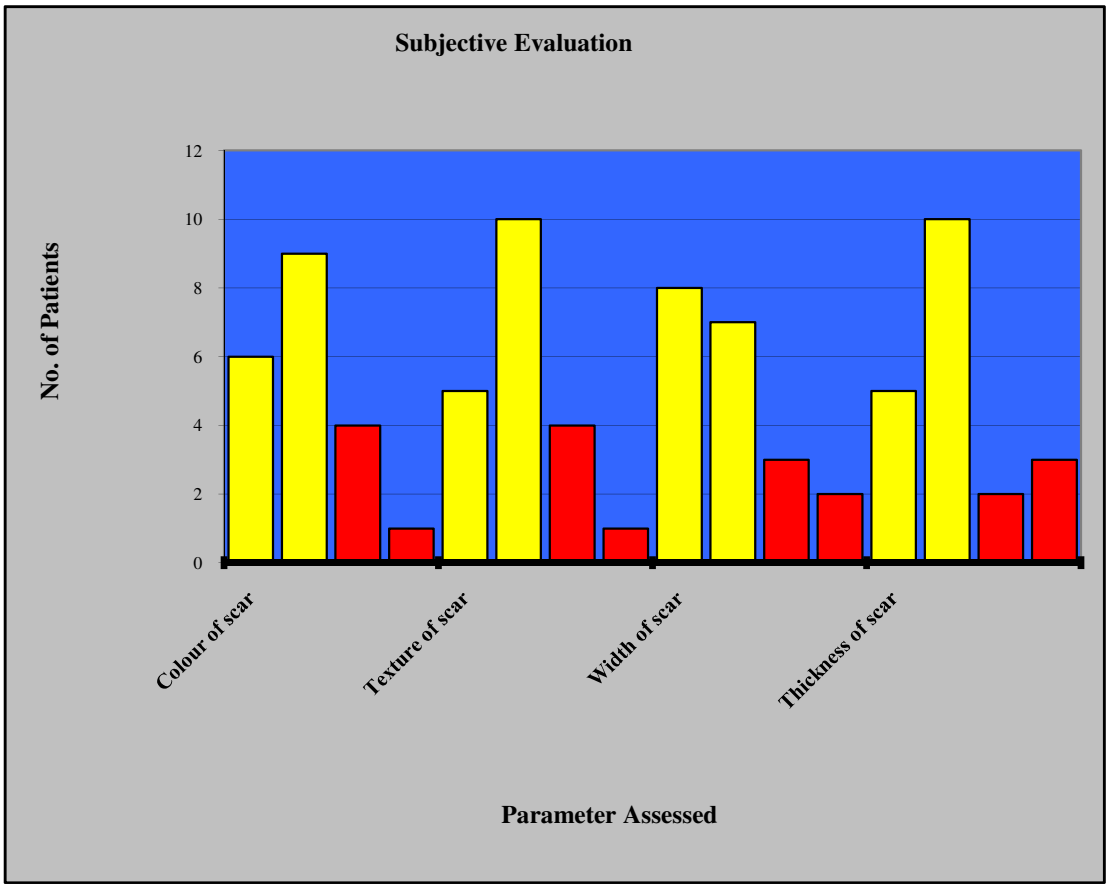


Figure 3.4 – Subjective Evaluation of Scar
Subjective evaluation of colour, texture, width and thickness of the scar.
The horizontal axis represents the parameter assessed as indicated in the graph. Each parameter has 4 columns representing the number of patients who were "very happy", "happy", "okay", and "unhappy", respectively. Clearly, the majority of the patients were relatively happy with these parameters as shown by the yellow areas.

Part of the Scar which created most concern

No patients were unhappy with the middle part of the scar, however, the upper and lower thirds created more concern (Table 3.4).

Ten patients (50%) were unhappy with the upper part of the scar and expressed the desire to have it revised or improved (Figure 3.5). Seven patients (35%) chose the lower part of the scar as the most concerning and would have it improved if possible (Figure 3.5).

The complaints in the upper part of the scar were related to an unattractive scar crossing the base of the columella. The complaints relating to the lower part of the scar were related to peaking of the vermilion skin junction and notching of the lip margin.

Table 3.4 – Patient happiness with upper, middle and lower part of scar

	Upper part of scar	**Middle part of Scar**	**Lower part of Scar**	**No particular area**
Number of Patients	10(50%)	0	7(35%)	3(15%)

Figure 3.5 – Graph Showing Most Bothersome Area of the scar

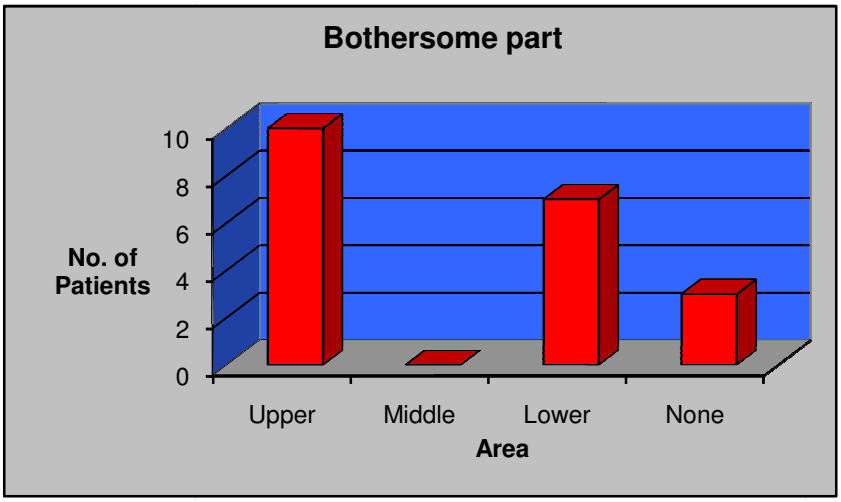


Figure 3.5 – Graph Showing Most Bothersome Area Of the Scar
Graph showing the results regarding the most bothersome part of the scar.
The horizontal axis represents the areas of the scar. The vertical axis represents the number of patients in each group. The upper part of the repair was clearly the most common area of concern.

3.3.2 OBJECTIVE EVALUATION

The most striking features that were noted from the objective evaluation were:

1. Virtually all patients had scar transgression of a normal anatomical boundary in the upper part of the lip, where the scar transgressed the philtral column. This is not surprising due to the nature of the Millard repair where additional vertical length on the medial aspect is gained by a curvilinear incision from the peak of Cupid's bow to the columella. This must then cross the philtral column (Figure 3.6).

2. There was a very high incidence of peaking (65%) and notching (45%) in this study group. It must be remembered that these patients have not had any secondary procedures since the initial cleft lip repair. The presence of notching or peaking is shown in table 3.5.

3. Cupid's bow to horizontal lip length ratio was greater in most patients as compared to normal (Figure 3.7). The ratio of the Cupid’s bow to horizontal lip length ratio in the normal group was 15–23%. In other words, the Cupid’s

bow occupied less than ¼ of the entire horizontal lip length. This was not the case with the repaired cleft group. In these patients, the Cupid's bow occupied at least 23% of the total horizontal lip length. That is, the repaired cleft lip group had a much larger Cupid's bow than that found in the normal group.

Table 3.5 – Presence of Peaking or Notching

	Present	**Absent**
NOTCHING	9(45%)	11(55%)
PEAKING	13(65%)	7(35%)

Figure 3.6 – Philtral Column Transgression with Millard Repair

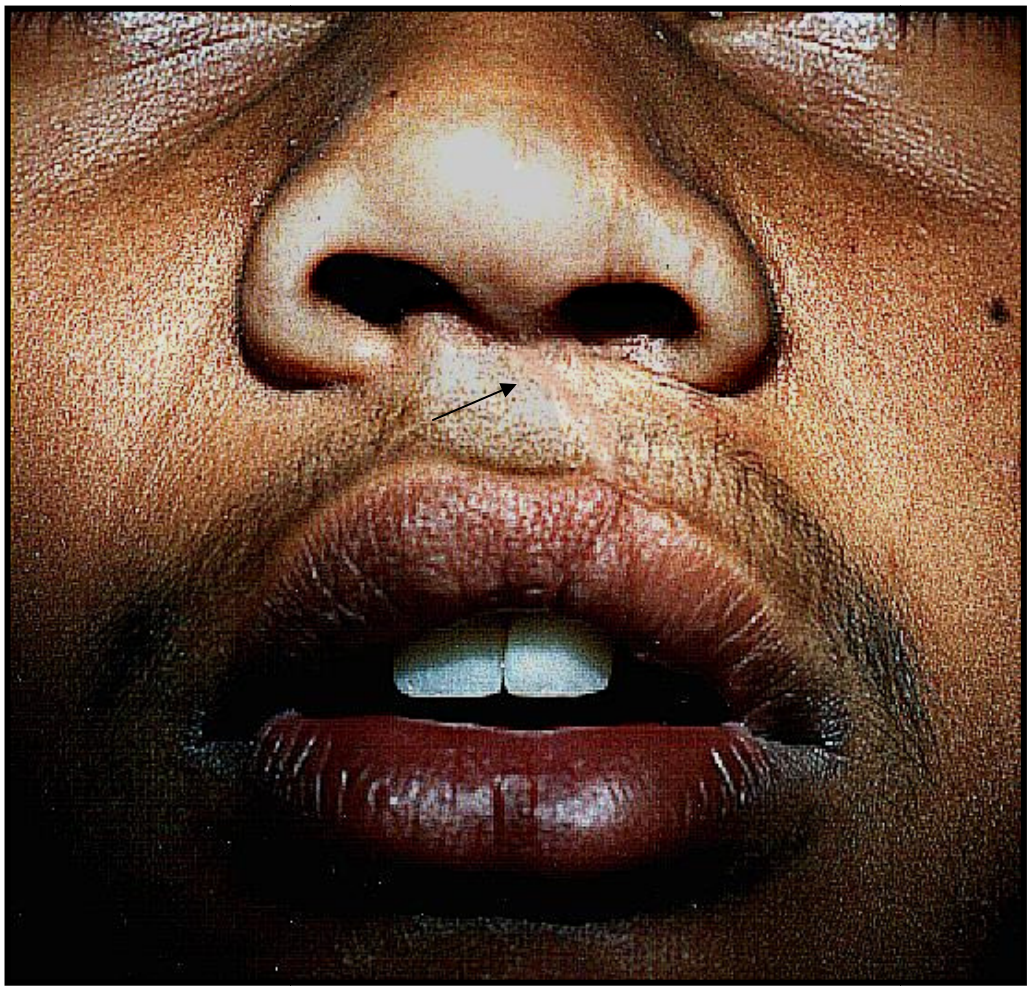


Figure 3.6
Figure of a 16 year old boy following a Millard cleft lip repair on the left, showing transgression of the philtral column in the upper part of the scar (arrow).

Figure 3.7 – Cupid's Bow to lip length ratio in Millard Repaired Lips

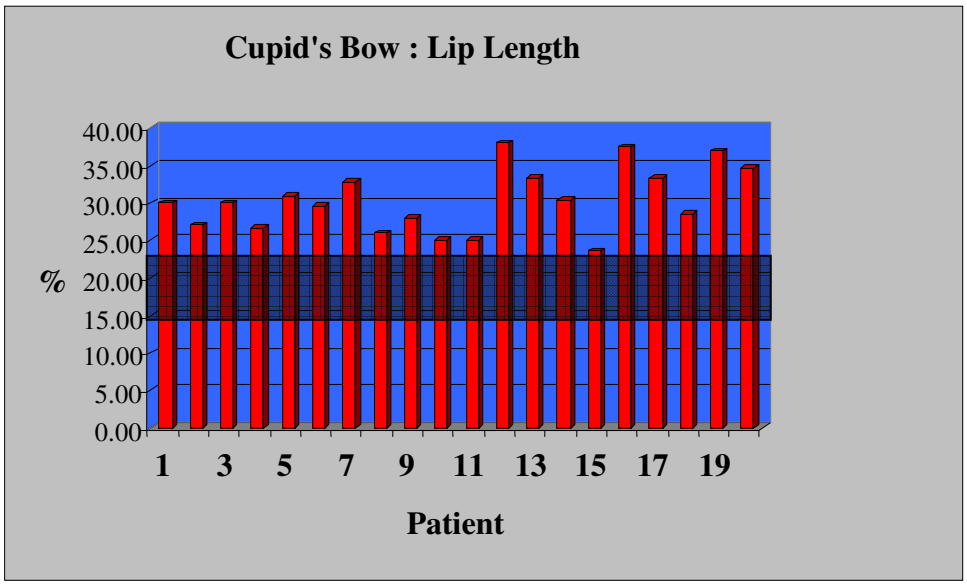


Figure 3.7
Graph representing the ratio occupied by Cupid's bow of the entire lip length. The x-axis indicates each of the 20 patients, the y-axis the ratio. Nineteen of the 20 patients had a Cupid's bow of at least 25% of the lip length. The ratio found in the normal population group was between 15% and 23% as shown by the darker shaded band.

3.4 Discussion

The ideal operation for the repair of a unilateral cleft lip would result in a symmetrical upper lip with the philtral column length on either side equal. The scar should mirror the opposite side and should not transgress the philtral column. There should also be no peaking at the Cupid's bow at the cleft side or notching of the vermilion. The Cupid's bow should be of adequate proportions as compared to the total horizontal lip length. The repair of a cleft lip without a scar is currently impossible.

These criteria should be obtainable in a single operation without multiple minor revisional procedures. Almost all operative procedures described have to a greater or lesser degree not complied with all the required criteria. When it was first described, it was felt that the Millard procedure would fulfill the majority of requirements of such an operation.

The initial objective of this study was to assess the long term result of the scar as seen from an objective and subjective point of view. However, additional interesting parameters where seen and were included in the study. These were the comparison

of the Cupid's bow to horizontal lip length ratio between the cleft and non-cleft patient groups, as well as the presence of notching of the vermilion and peaking at the Cupid's bow seen in our unrevised series.

The most obvious subjective and objective problem found pertained to the upper part of the scar just under the nostril sill. This is not surprising, as an anatomic boundary is breached in the upper part of the scar by nature of the Millard repair. In any plastic surgery procedure, adhering to general plastic surgical principles results in the most favourable outcome. One of these principles is to place incisions in natural skin creases and along natural anatomic boundaries. This is not different for the repair of a cleft lip. The problem with the Millard repair is that adequate vertical length would not be achieved on the medial side of the cleft if the philtral column is not breached. It is certain that if adequate length could be achieved without breaching this anatomic boundary, it would be appealing to most surgeons.

The second problem was that in many cases, although adequate lip length was achieved, there was some peaking at the Cupid's bow on the cleft side (no white-roll z-plasty was undertaken initially in any of these patients). This is probably due to

inadequate length obtained by the curvilinear line on the medial side of the cleft, resulting in a vertically short lip.

The third problem found was that many patients had vermilion notching. It is believed that the high incidence of notching results from the vermilion on the non-cleft side already beginning to taper at the level of the peak of Cupid's bow. This is the landmark for the Millard repair in an attempt to preserve the Cupid's bow width.

A further problem found related to the principle of preserving the entire Cupid's bow at all costs. This resulted in a proportionally larger Cupid's bow than that found in the normal population. This is not natural looking and has the added expense of breaching the philtral column to compensate for a shortage of vertical length. This principle must therefore be questioned.

It was therefore found that using this operative procedure did not in the majority of cases fulfill the ideal criteria that we have described for an ideal result using a single operation. It is also of great interest to find that using the principle of maintaining the Cupid's bow width at all costs resulted in a proportionally larger Cupid's bow than that found in the normal

population. This then begs the question whether it is worthwhile retaining the entire Cupid’s bow width at the expense of obtaining adequate lip length, alveolar notching and possible peaking.

3.5 Conclusion

The study has revealed two important facts:

1. The upper part of the scar close to the nose is problematic both from a subjective and objective point of view. It is important to note that the patients feel that the upper part of the scar is the most noticeable and that this is the area where the normal anatomical boundary of the philtral column is breached.
2. The ratio of Cupid's bow to the overall horizontal lip length seems to be large. This was measured against a small group of patients in this part of the study but this will be examined in further detail in the following chapter.

Chapter 4

THE ULTIMATE STRAIGHT LINE REPAIR FOR UNILATERAL CLEFT LIPS

4.1 Introduction

Chapter 2 has revealed the normal anatomical relationship of the separate lip segments and has highlighted the importance of the Cupid's bow ratio as compared to the entire horizontal lip length. More specifically, the Cupid's bow was less than 25% of the entire horizontal lip length at all ages that were examined from birth to adulthood. Interestingly, the growth spurts of the Cupid's bow was also shown which was different to that of the lateral lip segments (peak to ipsilateral commissure). The Cupid's bow seemed to grow faster than the lateral lip segments between ages 4 years to 16 years, after which the lateral lip segments seemed to grow more than the Cupid's bow. This may not be surprising as the philtrum and hence the Cupid's bow is derived from different embryological origins than the lateral lip segments.

The long term problems noted in the series of unilateral Millard cleft lip repairs examined in chapter 3, led to a prospective trial to simplify the procedure and achieve the following aims:

- A scar running vertically along the philtral column not crossing onto the philtrum.

- Lip height on the cleft side comparable to that on the non cleft side.

- To avoid peaking at the Cupid’s bow.

- To avoid notching (whistle tip) of the vermillion.

- To obtain a cupids bow width within the normal range.

- To achieve this with one operation.

4.2 **Operative Technique** (Figure 4.1)

1. Measure the vertical distance from the nostril sill adjacent to the columnella along the philtral column, to the peak of cupids bow on the normal side (AB).
2. Mark a point C at the nostril sill on the cleft side. Points A and C are equal distances from the columnella. Point C and A will therefore represent the start of the philtral columns on either side and must therefore be symmetrical.
3. Mark the same distance from sill on the cleft side to the vermillion (CD), this will pass the cupids bow peak and extend onto the cupids bow for a varying distance. Point D is invariably before where the vermillion border narrows.
4. Mark a point E on the nostril sill of the lateral segment that will result in the width of the nostril sill being equal to the normal side when the cleft is closed.
5. Point F is then marked on the vermilion border of the lateral lip segment such that lines EF, CD and AB are all equal (Figure 4.2). Point F will also extend beyond where the vermillion border narrows.

6. Points G and H are marked on the red line of Noordhof ensuring that there is sufficient vermilion to provide adequate fullness.
7. Full thickness incisions are made through the lip along lines CDG and EFH. The muscle is identified at the wound edges and released from any aberrant insertion .
8. The mucosa is then freed along the sulcus on either side.
9. Nasal correction can be performed if required.
10. The lip segments are then aligned and sutured in layers (mucosa, muscle, skin and vermillion) (Figure 4.3).

Figure 4.1 – Straight Line Repair

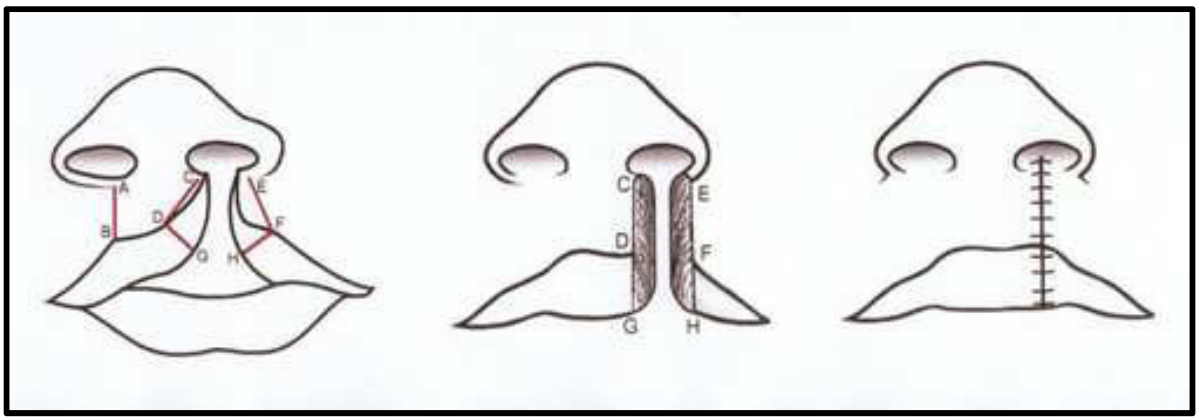


Figure 4.1 – Straight Line Repair.
Diagrammatic representation of the operation for the straight line repair.

Figure 4.2 – Patient with Pre-operative markings

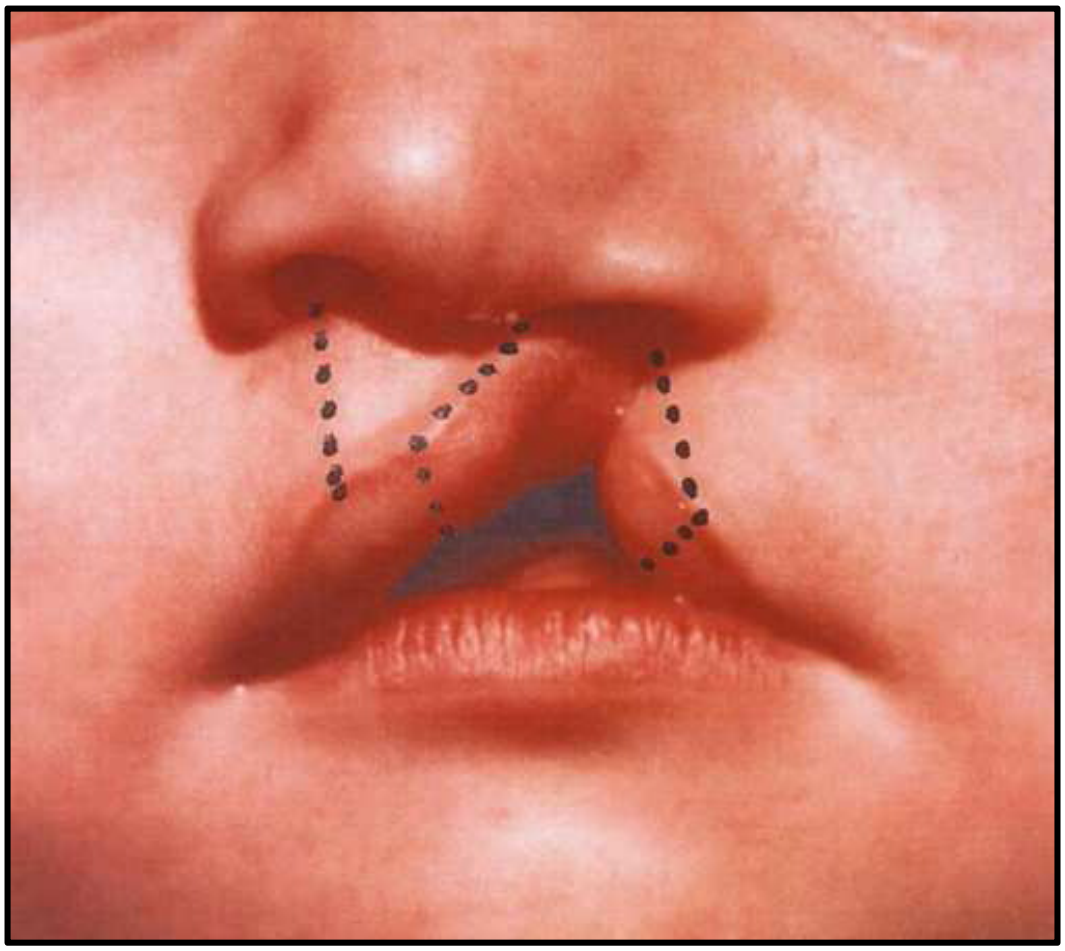


Figure 4.2.
Pre-operative markings on a patient for the straight line repair.

Figure 4.3 – Post-operative result of Straight Line repair

Figure 4.3 – Post-operative result of straight line repair
Alignment of the lip at the conclusion of surgery is shown here. There is good symmetry of the lip and adequate philtral height bilaterally

At the end of the procedure, the resultant straight line scar, does not infringe upon any anatomical boundaries, has an adequate lip length on the cleft side with no notching at the vermillion border. The only sacrifice is that the cupids bow width is compromised but this stretches out over time as does the lateral lip segment.

4.3 Materials and Methods

To date this procedure has been carried out in 46 patients over a period of roughly 12 years by two surgeons (Dr Christofides and Prof Chait). Nineteen patients of the 46 were assessed. These comprised 13 complete unilateral cleft lips and 6 incomplete unilateral cleft lips. Of the 27 patients that were not assessed, the post-operative time was too short in 17 patients and the remaining 10 were not available for follow up assessments.

At the time of assessing the post op repair the patients varied in age from 14 months to 12 years and 9 months with a mean of 50.3 months (4 years 1month). The timing of post operative assessment ranged from 11 months to 12 years with a mean of about 48 months (4 years).

Each of the 19 patients that were assessed had their age recorded and horizontal lip dimensions measured. The horizontal lip dimensions that were measured included the Cupid's bow width as well as the total horizontal lip length from commissure to commissure.

All measurements were performed during straight forward gaze without any animation of the lips.

4.4 Results

Table 4.1 – Measurements of upper lip dimensions for straight line cleft repair patients

Patient Number	Age (months)	C – C (mm)	P – P (mm)	PP/CC ratio (%)
1	14	32	6	18.75
2	16	42	8	19.05
3	16	38	7	18.42
4	12	34	6	17.65
5	54	40	9	22.50
6	82	45	11	24.44
7	28	37	8	21.62
8	76	50	12	24.00
9	65	44	9	20.45
10	94	49	11	22.45
11	20	39	7	17.95
12	44	39	8	20.51
13	52	45	11	24.44
14	18	39	9	23.08
15	34	41	9	21.95
16	78	39	8	20.51
17	65	43	9	20.93
18	35	37	8	21.62
19	153	59	11	18.64

Table 1 – Measurements of upper lip dimensions for straight line cleft repair patients
Age: Age is in months
C – C: Commissure to commissure measurement representing the entire horizontal lip length measured in millimeters
P – P: Cupid's bow peak to Cupid's bow peak measurement representing the width of the Cupid's bow measured in millimeters
PP/CC ratio: Ratio of the length of Cupid's bow measured from peak to peak on the one hand and the total lip length measured from commissure to commissure on the other representing the proportion of the horizontal lip length that is occupied by the Cupid's bow.

4.4.1 NATURE OF SCAR

The scars created a philtral column on the cleft side which was relatively symmetrical to that on the non-cleft side without breaching the philtrum itself. They remained flat with minimal stretching and no hypertrophic scars were seen.

4.4.2 HEIGHT OF LIP ON THE CLEFT SIDE (Figure 4.4 yellow lines)

This was exactly the same as the normal side in 17 patients (50%). In 12 patients (35%) the lip on the cleft side was 0.1cm shorter and in 3 (9%) the lip was 0.1cm's longer than the normal side. In the remaining 2 patients (6%) the lip height on the cleft side was 2mm shorter compared to the normal side. Thus in 32 patients (94%) the height of the lip at the cupid's bow peak on the cleft side varied by only 1mm as compared to the normal.

Figure 4.4 – Lip dimensions measured in the Patients with straight line cleft repair

Figure 4.4 - Lip dimensions measured in the Patients with straight line cleft repair

Measurements of lip dimensions:
 Yellow lines – Heights of philtral columns

 Blue line – Cupid's Bow width (peak to peak)

 Red line - Horizontal lip length (commissure to commissure)

4.4.3 PEAKING OF VERMILLION ON CLEFT SIDE

This occurred to a minimal degree in 4 patients (11%) and did not need revisional surgery. This would indicate that adequate length on the cleft side of the philtral column was obtained using the straight line repair.

4.4.4 NOTCHING OF THE LIP BORDER (WHISTLE TIP)

This was not seen in any of the patients. It would appear that the straight line repair for cleft lips does not predispose to notching of the vermilion. This could be because the vermilion has not started to taper at the points where the straight line repair is marked pre-operatively.

4.4.5 CUPIDS BOW WIDTH (Figure 4.4 – blue line)

The cupids bow width as a percent of the total horizontal lip width was calculated. This was obtained using the measurements of the commissure to commissure lip length (Figure 4.4 red line), and the peak to peak distance of Cupid's bow (Figure 4.4 blue line). A mean of 26% with a range of 18% – 36% was found. It should be noted that this proportion of Cupid's Bow width to the entire lip length correlates well with that of a normal lip as described in Chapter 2.

4.5 Discussion

When comparing our technique to the original straight line repair (Rose Thompson)[4,5,30], there are certain differences. The Rose Thompson technique is not truly a straight line repair as incisions on either side of the cleft are curvi-linear. The technique tries to maintain the full width of the original cupids bow and it is therefore difficult to get adequate lip length. We have also found that by doing this, the vermilion is retained at a point beyond which it has narrowed[31], thus resulting in the problem of notching at the vermillion border.

In the newly described straight line technique, the excision lines are straight (in the form of a V wedge excision) and in order to obtain adequate lip length on the cleft side, the incision extends to a varying degree beyond the point of the cupids bow peak on the cleft as well as the non cleft side. This is invariably before the point where the vermilion starts to narrow and therefore the problem of notching of the vermilion border is avoided[13]. Z-plasty's at the rim to prevent this are not necessary.

As this technique results in adequate lip length and little scar contracture, the incidence of peaking at the cupids bow on the cleft side was minimal.

At the end of the straight line operation, the Cupids Bow width to horizontal lip ratio may be smaller than that found in the classic techniques. Follow up measurements in this group of patients show the mean proportion of the Cupids Bow width as a percentage of total horizontal lip width to be comparable to that found in normal patients (Figure 4.5).

Figure 4.5 – Cupid's Bow to Lip Length Ratio Comparison Between Normal Population, Millard Repaired Cleft Lips and Straight Line Repaired Cleft Lips

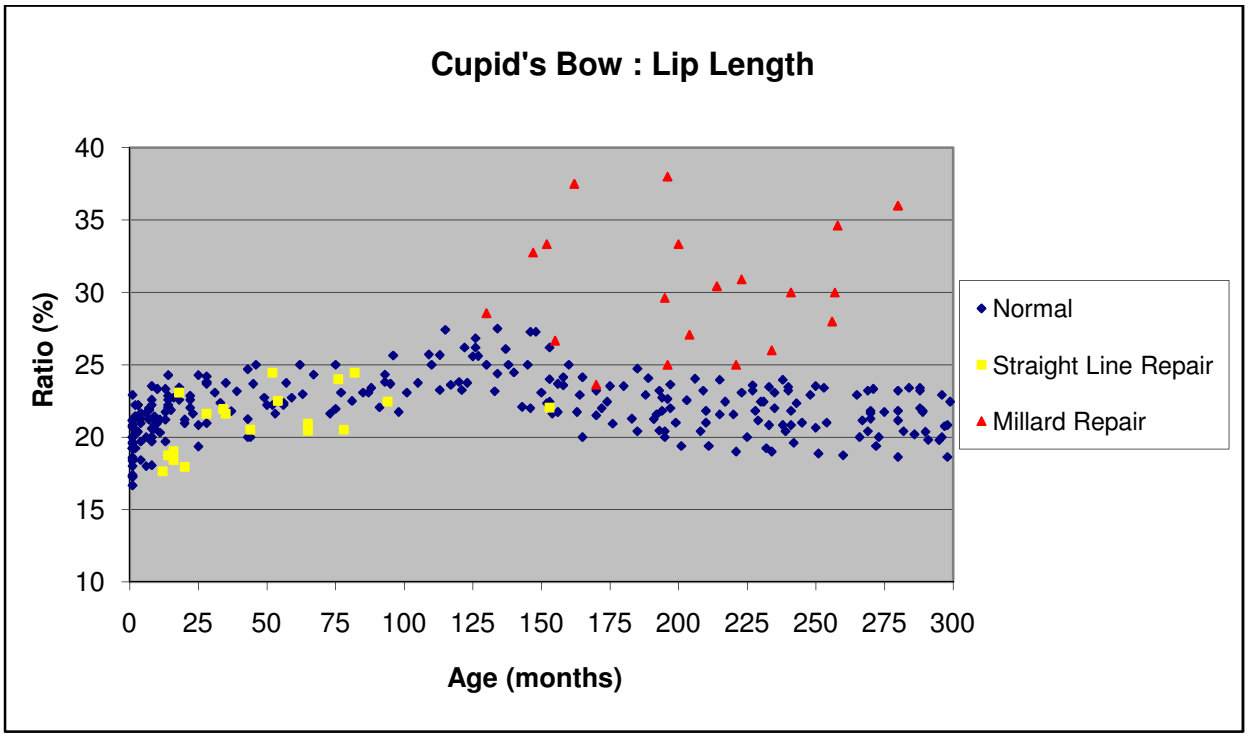


Figure 4.5 – Cupid's Bow to Lip Length Ratio Comparison Between Normal Population, Millard Repaired Cleft Lips and Straight Line Repaired Cleft Lips

The ratio of Cupid's bow to the total horizontal lip length is expressed as a percentage:

- normal people – blue dots (see chapter 2)
- Straight line repair patients – yellow dots
- Millard repair patients - red dots (see chapter 3)

The X-axis represents the age of the patient and the Y-axis represents the ratio between the total horizontal lip length and the Cupid's bow width

In chapter 3, the ratio of Cupid's Bow width to total horizontal lip width ratio was compared in a sample of 20 normal people and 20 long term follow up patients who had their unilateral cleft lips repaired by a classic Millard operation. The Cupid's Bow width in these patients was above the normal range.

Figure 4.5 shows the ratio of Cupid's Bow to horizontal lip length in the group of 272 normal people (blue points) investigated in chapter 2. Added to this are the 20 patients who underwent the Millard repair (red points) and the 19 patients who had the straight line repair (yellow points).

As can be seen, the Millard repair patients are mostly above the normal, whereas the straight line repair patients fall more within the normal range. From this graph we predict that in the long term, the ratio of Cupid's Bow to horizontal lip width would fall close to or within the normal range.

In a number of very wide cleft lip repairs, the vermillion border appeared thin at the end of the procedure. This appeared to be related to the tightness of the repair. Over time, with

stretching and relaxing of the lip structure this problem resolved.

The technique, although not perfect, is easily understood, reproducible and achieves a far better result in our hands than other procedures previously used (see Figures 4.6 – 4.10).

Figure 4.6 – Example 1 of straight line cleft lip repair showing before (A) and after (B) pictures

Figure 4.6A

Figure 4.6B

Figure 4.6 – Example 1 of straight line cleft lip repair showing before (A) and after (B) pictures
Complete right cleft lip, pre-operatively (Figure 4.6A) and post-operative (Figure 4.6B) result following a straight line

Figure 4.7 - Example 2 of straight line cleft lip repair showing before (A) and after (B) pictures

Figure 4.7A

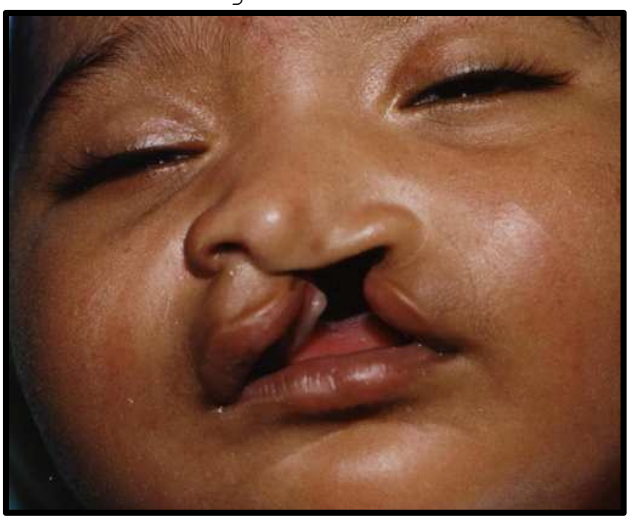


Figure 4.7B

Figure 4.7 – Example 2 of straight line cleft lip repair showing before (A) and after (B) pictures

Complete left cleft lip, pre-operatively (Figure 4.7A) and 2 year post-operative (Figure 4.7B) result following a straight line repair

Figure 4.8 – Example 3 of straight line cleft lip repair showing before (A) and after (B) pictures

Figure 4.8A

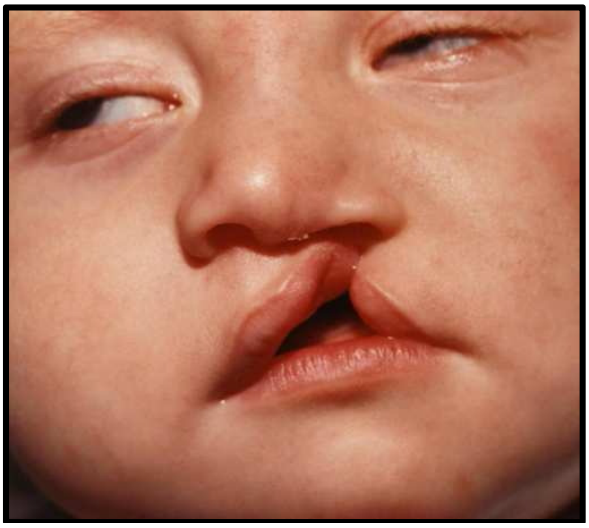


Figure 4.8B

Figure 4.8 – Example 3 of straight line cleft lip repair showing before (A) and after (B) pictures
Complete left cleft lip, pre-operatively (Figure 4.8A) and 1 year post-operative (Figure 4.8B) result following a straight line repair.

Figure 4.9 - Example 4 of straight line cleft lip repair showing before (A) and after (B) pictures

Figure 4.9A

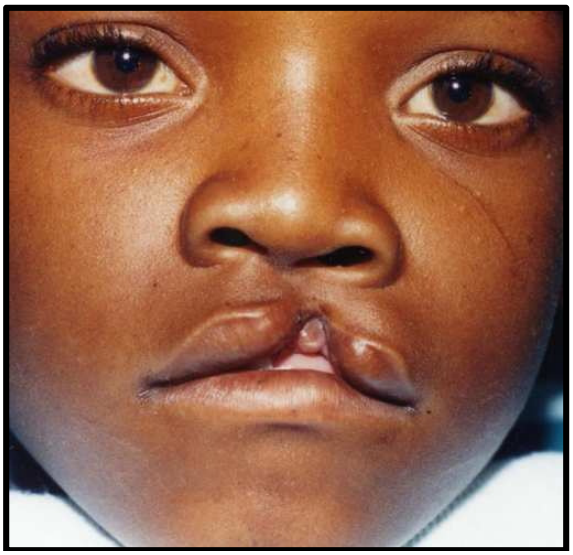


Figure 4.9B

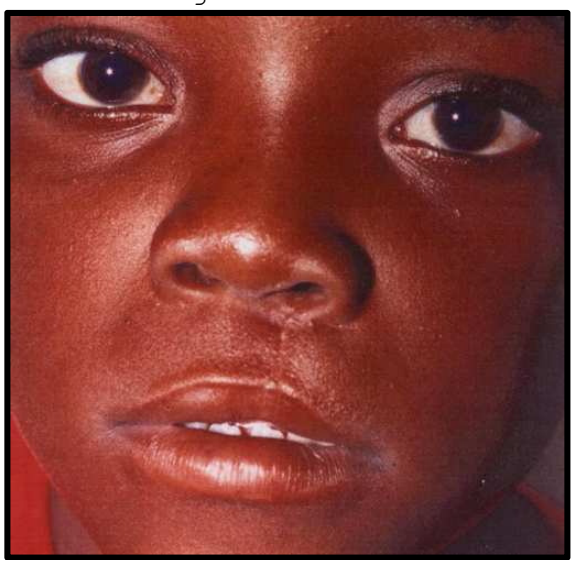


Figure 4.9 – Example 4 of straight line cleft lip repair showing before (A) and after (B) pictures
Incomplete left cleft lip in a 5year old boy, pre-operatively (Figure 4.9A) and 2 year post-operative (Figure 4.9B) result following a straight line repair.

Figure 4.10 – Example 5 of straight line cleft lip repair showing before (A) and after (B) pictures

Figure 4.10A

Figure 4.10B

Figure 4.10 – Example 5 of straight line cleft lip repair showing before (A) and after (B) pictures
Complete left cleft lip, pre-operatively (Figure 4.10A) and 3 year post-operative (Figure 4.10B) result following a straight line repair.

4.6 Conclusion

To date, the opinion of the parents regarding the scars in the younger patients as well as the subjective opinion of patients old enough to appreciate the results, has been very favourable. The criticisms found in our earlier study of patients who underwent Millard repairs have not been forthcoming.

We believe that when reverting to the original straight line repair with the modifications we've outlined, patients are much happier with their results without having to undergo multiple secondary procedures.

Chapter 5

CONCLUSION

The aims of a unilateral cleft lip repair are to achieve a lip length on the cleft side matching that on the normal side, an inconspicuous residual scar that does not cross anatomical boundaries, an adequate cupids bow width, an absence of notching of the vermillion border (whistle tip deformity), and there should be no peaking of the vermillion at the cleft side cupids bow.

Although a great number of operations have been described for the unilateral cleft lip repair, none fulfill all the above criteria and in most cases require secondary operations in an attempt to achieve this described goal.

The Millard operation for unilateral cleft lip deformity, with its various modifications, extensions and revisions[32,33,34,35,36,37,38,39], is the most widely practiced repair used today. In a recent survey, a subjective and objective assessment was made of 20 late follow up patients who had

undergone a Millard repair of their unilateral cleft lips. None of these patients had any subsequent revisional surgery. The results showed that 50% of the patients were unhappy with their scars in the upper third (1/3) (crossed anatomical philtral column) and 35% were unhappy about the lower 1/3 of the scar (where there was peaking of the cupids bow). Many also complained of vermillion notching.

The most interesting objective observation made was that the Cupid's bow width occupied a larger proportion of the total lip length (commissure to commissure) in the Millard repaired lips as compared to a study group of normal people of similar ages.

One can separate each of these problem areas in the residual scar and analyze its likely cause.

1) A scar that crosses normal anatomical boundaries.

   The normal philtral column lies in the vertical direction and is either straight or has a very slight curve. Scars which break this line cross anatomical boundaries and this breach occurs in most types of cleft lip operations including the Millard repair. This scar often becomes more obvious as the patient gets older.

2) Peaking at the Cupids Bow on the cleft side.

This occurs commonly due to scar contracture as well as an inadequate lip length achieved at the time of initial surgery.

3) Notching of the Vermilion

It can be noticed that in all cleft lips there is a point beyond which the vermilion begins to narrow on each side of the cleft. The principle of retaining the entire Cupid's Bow during the repair often results in the inclusion of the vermilion that has already started to thin. This invariably results in a notch at the vermilion border. Correction at the time of the operation often involves the inclusion of a Z-pasty which may create further irregularities.

In order to correct these problems so that the results conformed to the patient's desires, most of these patients required secondary operations. This took the form, in the majority of cases, of a full thickness wedge excision of the lip to include the scar. After realigning the lip structures, a straight line repair resulted.

It is also important to add at this point, that when considering excisional surgery for upper lip lesions, a wedge excision is always used if the lesion is small enough. This

will ultimately leave a vertical straight line scar which follows the normal anatomical lines and leaves the best possible result.

The straight line procedure which has been described in the previous chapter, has evolved over a period inspired by the secondary procedures performed on the Millard repair technique in an attempt to improve the result. This new technique eliminates many of the unwanted consequences of the Millard repair from the outset and results in an upper lip which has the anatomical dimensions similar to those of a normal non-cleft upper lip.

APPENDIX A

The following table shows the actual results obtained from the measurements that were taken. The table abbreviations are as follows:

C–C : Commissure to Commissure measurement (horizontal lip length).

P–P : Cupid’s bow peak to Cupid’s bow peak measurement (Cupid’s bow width).

L: C–P : Commissure to Cupid’s bow peak measurement on the left side (left lateral lip segment length).

R: C–P : Commissure to Cupid’s bow peak measurement on the right side (right lateral lip segment length).

P–P/C–C : Ratio of the length of Cupid’s bow measured from peak to peak on the one hand and the total lip length measured from commissure to commissure on the other.

No:	Age-m	Age-y	Age-w	Gender	C - C	P - P	L:C-P	R:C-P	PP/CC ratio
1	1	0.08	4	M	26	5	14.5	14.5	19.23
2	1	0.08	3	F	24	5	14.5	14.5	20.83
3	1	0.08	2	F	26.5	5.5	14	14	20.75
4	1	0.08	4	M	26	5.5	14	13	21.15
5	1	0.08	1	M	21.5	4	10.5	10.5	18.60
6	1	0.08	1	F	28	5.5	16	16	19.64
7	1	0.08	1	M	29	5	14	14	17.24
8	1	0.08	1	M	27	4.5	13	13	16.67
9	1	0.08	1	F	26	5	13	13	19.23
10	1	0.08	1	F	23	4	12	12	17.39
11	1	0.08	1	M	30	6	14	14	20.00
12	1	0.08	1	M	24.5	4.5	13	13	18.37
13	1	0.08	1	M	23	4.5	13	13	19.57
14	1	0.08	1	M	25	5	11	11	20.00
15	1	0.08	1	M	26	5	13	13	19.23
16	1	0.08	1	M	26	5	12	12	19.23
17	1	0.08	1	M	24	5.5	12	12.5	22.92
18	1	0.08	1	F	25	5	12	12.5	20.00
19	1	0.08	1	M	26	5.5	12.5	12.5	21.15
20	1	0.08	3	F	27	5	12	13	18.52
21	1	0.08	3	F	26	4.5	11	11	17.31
22	1	0.08	3	F	25	4.5	12	12	18.00
23	1	0.08	4	M	26	5.5	13	13	21.15
24	1	0.08	1	M	29	6	14	14	20.69
25	2	0.17	5	F	27	5.5	13	13	20.37
26	2	0.17	8	M	28	6	14	14	21.43
27	2	0.17	6	M	28	6	13	13	21.43
28	2	0.17	8.6	F	27	6	15	15	22.22
29	2	0.17	8.6	F	26	5	12	12	19.23
30	3	0.25	12.9	F	27	5.5	16	16	20.37
31	3	0.25	12.9	M	22.5	5	13.5	13.5	22.22
32	3	0.25	12.9	F	22.5	5	13	13	22.22
33	3	0.25	12.9	F	28	6	13	13	21.43
34	4	0.33	17.2	M	31	6.5	13.5	13.5	20.97
35	4	0.33	17.2	M	33	6.5	14	14	19.70
36	4	0.33	17.2	M	30	6.5	14	14	21.67
37	4	0.33	17.2	F	23.5	5	11	11	21.28
38	4	0.33	17.2	M	38	7	17	17	18.42
39	6	0.50	25.8	F	30	6.5	16	16	21.67
40	6	0.50	25.8	F	25	4.5	13	13	18.00
41	6	0.50	25.8	F	30	6	13.5	13.5	20.00
42	6	0.50	25.8	M	30	6.5	13.5	13.5	21.67
43	7	0.58	30.1	F	25	5.5	13	13	22.00

44	7	0.58	30.1	M	32	7	17	17	21.88
45	7	0.58	30.1	M	32	7	15	15	21.88
46	7	0.58	30.1	F	33	7	15	15	21.21
47	8	0.67	34.4	M	35	7	18	18	20.00
48	8	0.67	34.4	M	36	8	18	18	22.22
49	8	0.67	34.4	F	34	8	16	16	23.53
50	8	0.67	34.4	F	36	6.5	17	17	18.06
51	8	0.67	34.4	M	31	7	17	17	22.58
52	8	0.67	34.4	M	35	7	18	18	20.00
53	8	0.67	34.4	F	34	7	18	18	20.59
54	8	0.67	34.4	F	33	6.5	18	18	19.70
55	9	0.75	38.7	M	35	7.5	17	17	21.43
56	9	0.75	38.7	M	36	7.5	18	18	20.83
57	9	0.75	38.7	F	34	7	16	16	20.59
58	9	0.75	38.7	F	33	7	16	16	21.21
59	10	0.83	43	M	30	7	15	15	23.33
60	10	0.83	43	F	30	7	15	15	23.33
61	10	0.83	43	F	31	6.5	14	14	20.97
62	11	0.92	47.3	M	33	7	15.5	15.5	21.21
63	11	0.92	47.3	F	32	6.5	14	14	20.31
64	13	1.08	55.9	F	33	7	16	16	21.21
65	14	1.17	60.2	M	34	7.5	16	16	22.06
66	13	1.08	55.9	F	33	6.5	17	17	19.70
67	13	1.08	55.9	M	30	7	14	14	23.33
68	13	1.08	55.9	F	34.5	7.5	17	16.5	21.74
69	14	1.17	60.2	M	36	8	18	18	22.22
70	14	1.17	60.2	F	35	8	17	17	22.86
71	14	1.17	60.2	M	35	8.5	18	18	24.29
72	14	1.17	60.2	F	31	7	17	17	22.58
73	15	1.25	64.5	F	32	7	16	16	21.88
74	16	1.33	68.8	M	33	7.5	17	17	22.73
75	18	1.50	77.4	M	32	7.5	17	17	23.44
76	18	1.50	77.4	F	31	7	17	17	22.58
77	20	1.67	86	F	31	6.5	17	17	20.97
78	20	1.67	86	M	34	8	17	17	23.53
79	20	1.67	86	F	33	7	17	17	21.21
80	22	1.83	94.6	M	31	7	15	15	22.58
81	22	1.83	94.6	M	35	8	16	16	22.86
82	22	1.83	94.6	M	29.5	6.5	19	19	22.03
83	23	1.92	98.9	M	37	8	18.5	18.5	21.62
84	25	2.08	107.5	M	35	8.5	17	17	24.29
85	25	2.08	107.5	F	31	6	18	18	19.35
86	25	2.08	107.5	M	36	7.5	19	19	20.83
87	28	2.33	120.4	F	31	7.5	16.5	16	24.19
88	28	2.33	120.4	M	42	10	21	21	23.81
89	28	2.33	120.4	F	31	6.5	17	17	20.97
90	28	2.33	120.4	F	38	9	15	16	23.68
91	31	2.58	133.3	M	39	9	16	16	23.08

92	33	2.75	141.9	F	38	8.5	16	16	22.37
93	35	2.92	150.5	M	40	9.5	16	16	23.75
94	36	3.00	154.8	F	35	7	16	16	20.00
95	37	3.08	159.1	F	38	7.5	16	16	19.74
96	37	3.08	159.1	F	39	8.5	17	17	21.79
97	39	3.25	167.7	M	41	9.5	17	18	23.17
98	43	3.58	184.9	F	40.5	10	20	20	24.69
99	43	3.58	184.9	F	35	7	16	16	20.00
100	43	3.58	184.9	M	40	8.5	19	19	21.25
101	44	3.67	189.2	F	35	7	16	16	20.00
102	45	3.75	193.5	M	38	9	18	18	23.68
103	46	3.83	197.8	M	38	9.5	18	17	25.00
104	49	4.08	210.7	M	33	7.5	15	15	22.73
105	50	4.17	215	F	36	8	16	16	22.22
106	52	4.33	223.6	F	36	8	18	19	22.22
107	53	4.42	227.9	M	37	8	17	17	21.62
108	56	4.67	240.8	F	38	8.5	20	21	22.37
109	56	4.67	240.8	F	36	8	16	16	22.22
110	57	4.75	245.1	M	40	9.5	22	22	23.75
111	59	4.92	253.7	M	33	7.5	15	15	22.73
112	62	5.17	266.6	F	36	9	19	19	25.00
113	63	5.25	270.9	F	37	8.5	18	18	22.97
114	67	5.58	288.1	F	37	9	18	17	24.32
115	73	6.08	313.9	M	37	8	17	17	21.62
116	75	6.25	322.5	M	40	10	16	16	25.00
117	75	6.25	322.5	M	41	9	19.5	19	21.95
118	77	6.42	331.1	M	39	9	18	18	23.08
119	81	6.75	348.3	F	40	9	22	22	22.50
120	85	7.08	365.5	M	39	9	18	18	23.08
121	87	7.25	374.1	M	39	9	17	17	23.08
122	88	7.33	378.4	F	47	11	22	23	23.40
123	91	7.58	391.3	F	34	7.5	20	20	22.06
124	93	7.75	399.9	M	37	9	18	18	24.32
125	93	7.75	399.9	F	31.5	7.5	18	18	23.81
126	95	7.92	408.5	F	38	9	20	20	23.68
127	96	8.00	412.8	M	39	10	16	16	25.64
128	98	8.17	421.4	M	46	10	19.5	20	21.74
129	101	8.42	434.3	F	39	9	18	18	23.08
130	105	8.75	451.5	M	40	9.5	18	18	23.75
131	109	9.08	468.7	F	35	9	14	15	25.71
132	110	9.17	473	M	40	10	16.5	16.5	25.00
133	113	9.42	485.9	F	37	9.5	20	20	25.68
134	113	9.42	485.9	M	43	10	22	22	23.26
135	115	9.58	494.5	F	31	8.5	17	17	27.42
136	117	9.75	503.1	M	36	8.5	19	19	23.61
137	120	10.00	516	F	42	10	19	19	23.81
138	121	10.08	520.3	M	43	10	19	19	23.26
139	122	10.17	524.6	M	42	11	19	19	26.19

140	123	10.25	528.9	F	40	9.5	17	17	23.75
141	125	10.42	537.5	M	43	11	19	19	25.58
142	126	10.50	541.8	F	42	11	19	19	26.19
143	126	10.50	541.8	M	41	11	18	18	26.83
144	127	10.58	546.1	F	41	10.5	17	17	25.61
145	130	10.83	559	M	42	10.5	18	18	25.00
146	133	11.08	571.9	F	41	9.5	19	19	23.17
147	134	11.17	576.2	F	40	11	17	18	27.50
148	134	11.17	576.2	M	41	10	19	19	24.39
149	137	11.42	589.1	M	46	12	19	19	26.09
150	138	11.50	593.4	F	44	11	19	19	25.00
151	140	11.67	602	M	47	11.5	18	18	24.47
152	143	11.92	614.9	M	43	9.5	26	25	22.09
153	145	12.08	623.5	F	48	12	23	24	25.00
154	146	12.17	627.8	M	44	12	21	21	27.27
155	146	12.17	627.8	M	50	11	25	25	22.00
156	148	12.33	636.4	F	44	12	20	20	27.27
157	150	12.50	645	F	39	9	19	19	23.08
158	152	12.67	653.6	M	47	10.5	24	24	22.34
159	153	12.75	657.9	M	49	11	23	23	22.45
160	153	12.75	657.9	F	42	11	18.5	18.5	26.19
161	153	12.75	657.9	M	50	12	24	24	24.00
162	154	12.83	662.2	M	37	8	21	21	21.62
163	156	13.00	670.8	F	38	9	19	19	23.68
164	156	13.00	670.8	M	46	10	23	23	21.74
165	158	13.17	679.4	F	53	12.5	23	22	23.58
166	158	13.17	679.4	M	43.5	10.5	21.5	21.5	24.14
167	160	13.33	688	M	42	10.5	16.5	16.5	25.00
168	163	13.58	700.9	F	46	10	20	20	21.74
169	164	13.67	705.2	M	48	11	23	23	22.92
170	165	13.75	709.5	F	50	10	24	24	20.00
171	165	13.75	709.5	M	43.5	10.5	22	24	24.14
172	170	14.17	731	M	56	13	24	24	23.21
173	170	14.17	731	M	46.5	10	20	21	21.51
174	172	14.33	739.6	F	50	11	24	24	22.00
175	174	14.50	748.2	M	49	11	23	23.5	22.45
176	175	14.58	752.5	M	51	12	24	24	23.53
177	176	14.67	756.8	F	43	9	18	18	20.93
178	180	15.00	774	F	51	12	25	24	23.53
179	183	15.25	786.9	F	47	10	22	22	21.28
180	185	15.42	795.5	F	46.5	11.5	22	21	24.73
181	185	15.42	795.5	M	49	10	24	24	20.41
182	188	15.67	808.4	F	48	11	23	23	22.92
183	189	15.75	812.7	M	54	13	24	24	24.07
184	191	15.92	821.3	M	40	8.5	18	17	21.25
185	192	16.00	825.6	M	51	11	23	23	21.57
186	193	16.08	829.9	F	44	9	18	19	20.45
187	193	16.08	829.9	M	56	13	22	22	23.21

188	194	16.17	834.2	F	55	12	21	21	21.82
189	194	16.17	834.2	F	44	10	19	19	22.73
190	195	16.25	838.5	M	50	10	22	22	20.00
191	195	16.25	838.5	M	49	10	25	26	20.41
192	196	16.33	842.8	F	53	12	20	20	22.64
193	197	16.42	847.1	M	55	13	24	24	23.64
194	197	16.42	847.1	F	50	11	22	22	22.00
195	199	16.58	855.7	M	50	10.5	22	22	21.00
196	201	16.75	864.3	F	49	9.5	23	23	19.39
197	203	16.92	872.9	M	51	11.5	22	23	22.55
198	206	17.17	885.8	F	52	12.5	26	26	24.04
199	208	17.33	894.4	F	49	10	21	21	20.41
200	209	17.42	898.7	M	56	13	22	22	23.21
201	210	17.50	903	F	55	12	21	21	21.82
202	211	17.58	907.3	M	49	9.5	23	23	19.39
203	210	17.50	903	F	50	10.5	25	25	21.00
204	215	17.92	924.5	M	51	11	26	26	21.57
205	215	17.92	924.5	M	48	11.5	20	20	23.96
206	217	18.08	933.1	F	49	11	25	25	22.45
207	220	18.33	946	F	51	11	26	26	21.57
208	221	18.42	950.3	F	50	9.5	24	24	19.00
209	223	18.58	958.9	M	52	12	25	25	23.08
210	225	18.75	967.5	F	50	10	24	24	20.00
211	227	18.92	976.1	M	53	12.5	26	26	23.58
212	227	18.92	976.1	M	56	13	22	22	23.21
213	228	19.00	980.4	F	55	12	21	21	21.82
214	229	19.08	984.7	F	52	11	25	25	21.15
215	230	19.17	989	M	49	11	25	25	22.45
216	231	19.25	993.3	M	49	11	25	25	22.45
217	232	19.33	997.6	F	52	10	24	24	19.23
218	233	19.42	1001.9	F	48	10	23	23	20.83
219	233	19.42	1001.9	M	49	11.5	23	23	23.47
220	234	19.50	1006.2	F	50	9.5	23	23	19.00
221	235	19.58	1010.5	M	50	11	22	22	22.00
222	235	19.58	1010.5	M	52	12	24	24	23.08
223	238	19.83	1023.4	M	48	11.5	20	20	23.96
224	238	19.83	1023.4	F	48	10	20	20	20.83
225	239	19.92	1027.7	F	49	10	21	21	20.41
226	240	20.00	1032	F	49	11.5	24	23.5	23.47
227	240	20.00	1032	M	56	13	22	22	23.21
228	241	20.08	1036.3	M	55	12	21	21	21.82
229	241	20.08	1036.3	F	48	10	23	23	20.83
230	242	20.17	1040.6	F	51	10	24	24	19.61
231	243	20.25	1044.9	F	47	10.5	22	22	22.34
232	245	20.42	1053.5	M	50	10.5	23	23	21.00
233	248	20.67	1066.4	M	48	11	22	22	22.92
234	250	20.83	1075	F	46	9.5	22	22	20.65
235	250	20.83	1075	F	51	12	21.5	22	23.53

236	251	20.92	1079.3	F	53	10	24	24	18.87
237	253	21.08	1087.9	M	47	11	22	22	23.40
238	254	21.17	1092.2	F	50	10.5	24	24	21.00
239	260	21.67	1118	F	48	9	23	23	18.75
240	265	22.08	1139.5	F	48	11	19	19	22.92
241	266	22.17	1143.8	F	50	10	24	24	20.00
242	267	22.25	1148.1	M	52	11	25	25	21.15
243	269	22.42	1156.7	F	49	10	22	21	20.41
244	269	22.42	1156.7	M	56	13	22	22	23.21
245	270	22.50	1161	M	55	12	21	21	21.82
246	270	22.50	1161	F	47	10	22	22	21.28
247	270	22.50	1161	F	48.5	10.5	22	21.5	21.65
248	271	22.58	1165.3	M	45	10.5	21	21	23.33
249	272	22.67	1169.6	F	49	9.5	23	23	19.39
250	273	22.75	1173.9	F	42.5	8.5	19	19	20.00
251	275	22.92	1182.5	F	46	10	21	21	21.74
252	280	23.33	1204	F	51	9.5	24	24	18.63
253	280	23.33	1204	M	56	13	22	22	23.21
254	280	23.33	1204	M	55	12	21	21	21.82
255	280	23.33	1204	F	52	11	26	26	21.15
256	282	23.50	1212.6	M	49	10	22	21	20.41
257	284	23.67	1221.2	F	47	11	23	23	23.40
258	286	23.83	1229.8	F	52	10.5	24	23	20.19
259	288	24.00	1238.4	M	50	11	24	24	22.00
260	288	24.00	1238.4	M	47	11	22	22	23.40
261	288	24.00	1238.4	M	56	13	22	22	23.21
262	289	24.08	1242.7	F	55	12	21	21	21.82
263	289	24.08	1242.7	F	46	10	21	21	21.74
264	290	24.17	1247	M	54	11	25	25	20.37
265	291	24.25	1251.3	F	53	10.5	24	24	19.81
266	295	24.58	1268.5	F	48	9.5	25	25	19.79
267	296	24.67	1272.8	M	48	11	24	24	22.92
268	296	24.67	1272.8	F	42.5	8.5	19	19	20.00
269	297	24.75	1277.1	F	53	11	25	25	20.75
270	298	24.83	1281.4	F	48	10	24	24	20.83
271	298	24.83	1281.4	F	51	9.5	24	24	18.63
272	299	24.92	1285.7	M	49	11	24	24	22.45

APPENDIX B

STATISTICS

Table B1 – Means of the lip dimensions measured in normal people for the different age categories

		C - C	C - C	P - P	P - P	L: C – P	L: C – P	R: C - P	R: C - P	P-P/C-C ratio	P-P/C-C ratio
Age_grp	n	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.	Means	Std.Dev.
1 (0-1m)	24	25.81250	1.988076	5.02083	0.541318	12.91667	1.299387	12.95833	1.241639	19.45292	1.522102
2 (1-12m)	37	30.58108	4.045769	6.43243	0.859281	15.10811	1.976020	15.10811	1.976020	21.07135	1.346762
3 (1-4y)	42	34.89286	3.365057	7.76190	1.043202	16.91667	1.426734	16.91667	1.409535	22.20429	1.499211
4 (4-7.9y)	23	37.45652	3.215421	8.63043	0.868873	18.23913	2.077310	18.30435	2.224549	23.03174	0.993971
5 (8-11.9y)	26	40.92308	3.486237	10.11538	0.897861	18.53846	2.144402	18.59615	1.918433	24.76231	1.541475
6 (12-15.9y)	32	46.59375	4.574539	10.76563	1.257137	21.92188	2.296945	21.93750	2.361485	23.12438	1.793015
7 (16-19.9y)	41	50.70732	2.856956	11.02439	1.117761	22.80488	2.076289	22.87805	2.051769	21.71659	1.482162
8 (>20y)	47	49.98936	3.516250	10.69149	1.106076	22.64894	1.638248	22.57447	1.648381	21.37936	1.485442
All Grps	272	40.66728	9.264490	8.98897	2.269619	19.05147	3.877163	19.06618	3.866217	22.01408	1.973013

Table B1

Table B1shows the statistical analysis of each of the eight different age categories together with a standard deviation. The abbreviations used are as follows:

C-C : Commissure to Commissure measurement (horizontal lip length).

P-P : Cupid's bow peak to Cupid's bow peak measurement (Cupid's bow width).

L: C-P : Commissure to Cupid's bow peak measurement on the left side (left lateral lip segment length).

R: C-P : Commissure to Cupid's bow peak measurement on the right side (right lateral lip segment length).

P-P/C-C : Ratio of the length of Cupid's bow measured from peak to peak on the one hand and the total lip length measured from commissure to commissure on the other.

Table B2: Scheffe Test; Variable: P-P

P – P: Marked differences are significant at p-values <0.0500

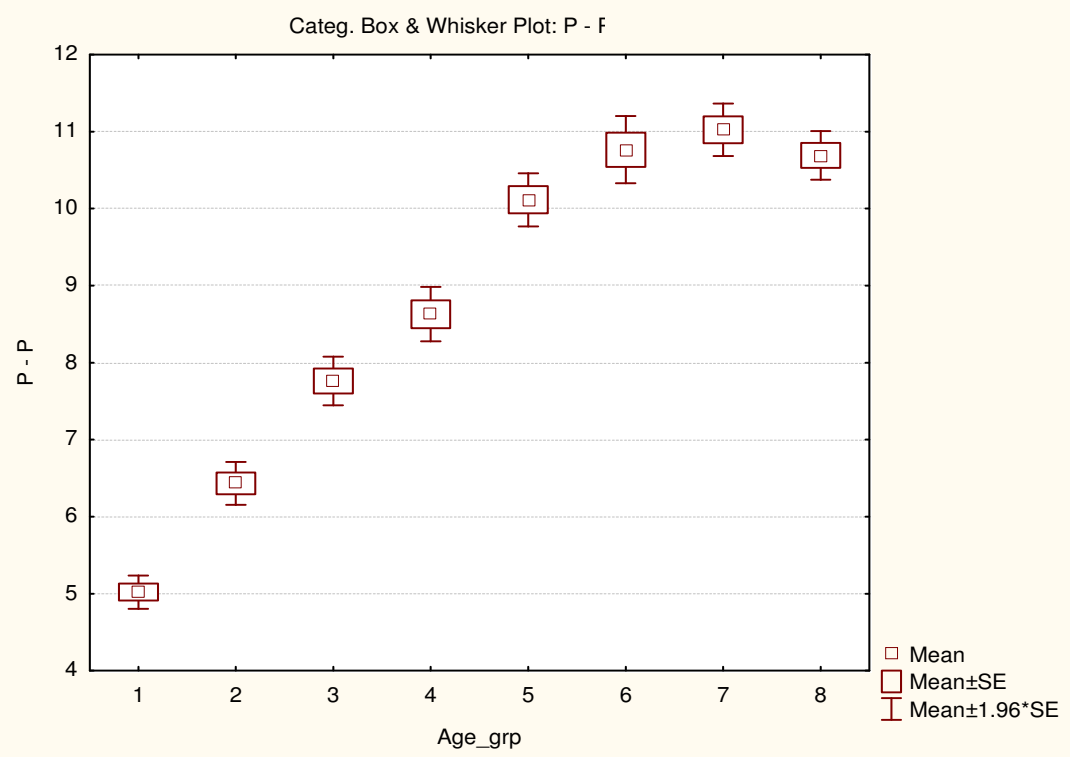
Age Grp		{1} M=5.0208	{2} M=6.4324	{3} M=7.7619	{4} M=8.6304	{5} M=10.115	{6} M=10.766	{7} M=11.024	{8} M=10.691
1	{1}		0.000307	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	{2}	0.000307		0.000036	0.000000	0.000000	0.000000	0.000000	0.000000
3	{3}	0.000000	0.000036		0.145601	0.000000	0.000000	0.000000	0.000000
4	{4}	0.000000	0.000000	0.145601		0.000665	0.000000	0.000000	0.000000
5	{5}	0.000000	0.000000	0.000000	0.000665		0.548980	0.080519	0.607760
6	{6}	0.000000	0.000000	0.000000	0.000000	0.548980		0.991259	0.999997
7	{7}	0.000000	0.000000	0.000000	0.000000	0.080519	0.991259		0.935505
8	{8}	0.000000	0.000000	0.000000	0.000000	0.607760	0.999997	0.935505	

Table B2

Table B2 is a Scheffe test for Cupid's bow width. This shows the statistical difference between the different age group measurements for the Cupid's bow width (P-P) using p-values. A significant difference between different age groups is indicated by a p-value of less than 0.05. If the p-value is greater than 0.05, then this would imply that there is very little difference in the measurements between those age groups. For example, the p-value comparing groups 6 and 7 is 0.99 which would indicate very little growth in the Cupid's bow in that time. Similarly, it can be noted that there is a marked difference in the values between age group 4 and age group 5 which would indicate a significant difference. In this case, it would indicate a growth spurt of the Cupid's bow between age group 4 and age group 5. In Summary, there has been no significant difference in the measurements obtained between age

groups 3 and 4 and also between age groups 5, 6, 7, and 8. This is shown graphically in graph B1.

Graph B1 – Cupids Bow width for each age category



Graph B1

Graph B1 shows the Cupid's bow measurements in the different age groups. The X-axis (Age grp) represents the different age groups from age group 1 to age group 8. The Y-Axis (P-P) represents the Cupid's bow width as measured from peak to peak in millimetres. The small square is the mean for that age group; the bigger square is the mean plus the standard error and the whiskers represent the mean plus double the standard error. If the whiskers of the different age groups are close

together along the plane of the Y-axis, then there is little significant difference between the measurements in those age groups. For example, there is overlap between the squares and whiskers along the Y-axis in age groups 6, 7 and 8 indicating that the Cupid's bow has not increased in length dramatically between these ages. Similarly, there is a marked difference between age groups 1 and 2, as well as between age groups 4 and 5 which would indicate a growth spurt in the width of the Cupid's bow between those age groups.

Table B3: Scheffe Test; Variable: L: C – P

L:C–P: Marked differences are significant at p-values <0.0500

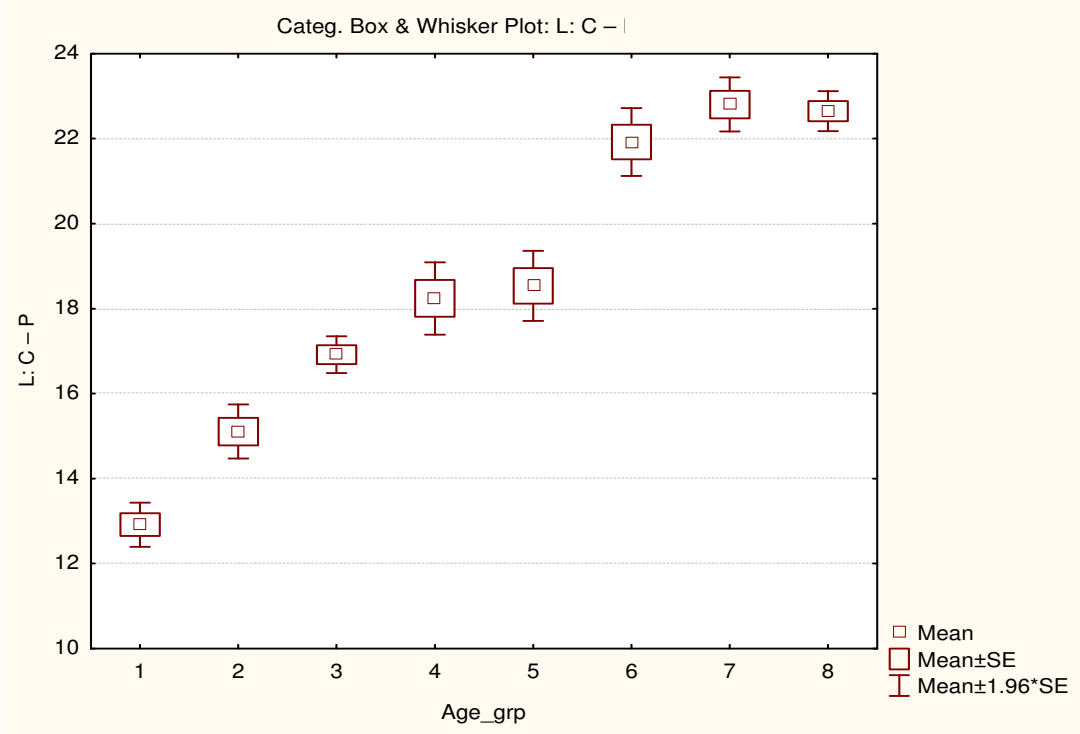
Age Grp		{1} M=12.917	{2} M=15.108	{3} M=16.917	{4} M=18.239	{5} M=18.538	{6} M=21.922	{7} M=22.805	{8} M=22.649
1	{1}		0.007381	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	{2}	0.007381		0.012976	0.000005	0.000000	0.000000	0.000000	0.000000
3	{3}	0.000000	0.012976		0.395504	0.107024	0.000000	0.000000	0.000000
4	{4}	0.000000	0.000005	0.395504		0.999885	0.000000	0.000000	0.000000
5	{5}	0.000000	0.000000	0.107024	0.999885		0.000000	0.000000	0.000000
6	{6}	0.000000	0.000000	0.000000	0.000000	0.000000		0.782523	0.897509
7	{7}	0.000000	0.000000	0.000000	0.000000	0.000000	0.782523		0.999990
8	{8}	0.000000	0.000000	0.000000	0.000000	0.000000	0.897509	0.999990	

Table B3

Table B3 is a Scheffe test for the left lateral lip as measured from the left peak of Cupid's bow to the left commissure of the lip (C). This shows the statistical difference between the different age group measurements for the left lateral lip

segment (L:C-P) using p-values. A significant difference between different age groups is indicated by a p-value of less than 0.05. If the p-value is greater than 0.05, then this would imply that there is very little difference in the measurements between those age groups. For example, the p-value comparing groups 6, 7 and 8 are greater than 0.78 indicating that there is no significant difference in these age groups. In other words, there has been no significant growth in the lateral lip segment between age groups 6 and 8. Similarly, there is no significant growth between age groups 3, 4 and 5. There is however a significant increase in the growth between age groups 5 and 6 with a p-value of 0.0000. This would indicate a growth spurt of the left lateral segment between age group 5 and 6. There is also significant growth of the lateral segment between age groups 1, 2, 3 and 4 as indicated by a p-value of less than 0.05. This is shown graphically in graph B2.

Graph B2 – Left lateral lip segment length for each age category



Graph B2

Graph B2 shows the growth of the left lateral segment of the upper lip. The X-axis (Age grp) represents the different age groups from age group 1 to age group 8. The Y-Axis (L:C-P) represents the lateral lip segment length as measured from the left peak of Cupid's bow to the left commissure of the lip (C). The small square is the mean for that age group; the bigger square is the mean plus the standard error and the whiskers represent the mean plus double the standard error. If the whiskers of the different age groups are close together along the plane of the Y-axis, then there is little significant

difference between the measurements in those age groups. For example, there is overlap between the squares and whiskers along the Y-axis in age groups 4 and 5 indicating that the lateral lip segment has not increased in length dramatically between these ages. Similarly, there is a marked difference between age groups 1 and 2, as well as between age groups 5 and 6 which would indicate a growth spurt in the lateral lip segment between those age groups.

Table B4: Scheffe Test; Variable: R: C – P

L:C–P: Marked differences are significant at p-values <0.0500

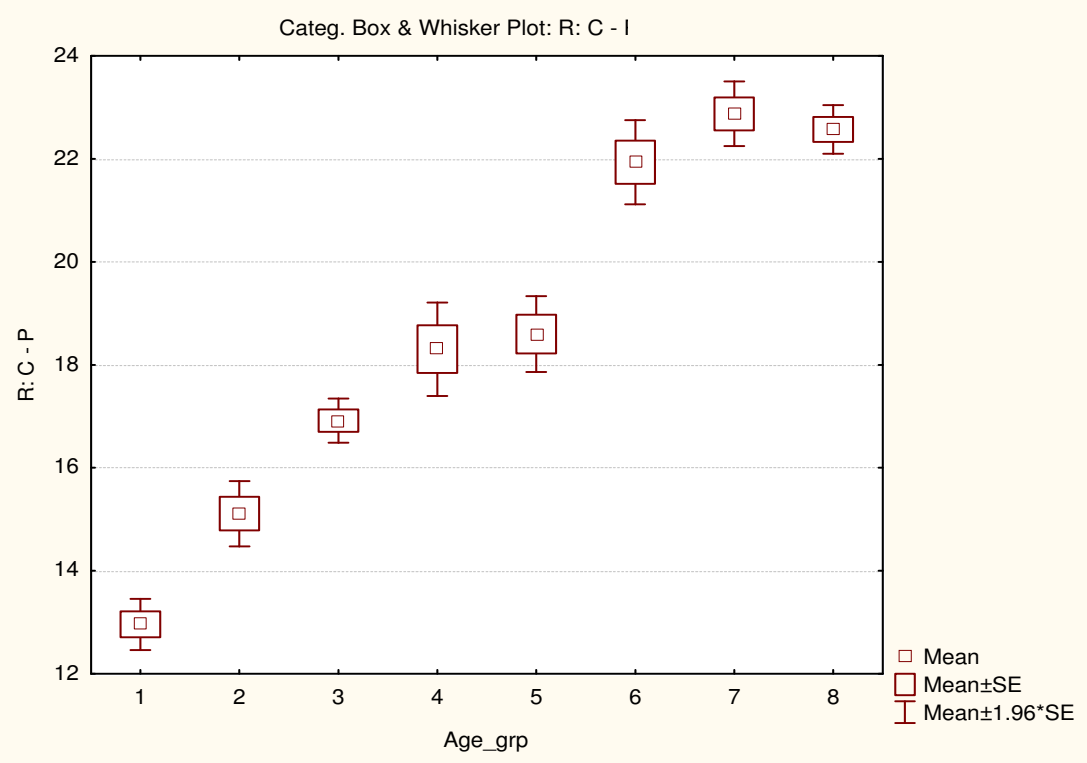
Age Grp		{1} M=12.958	{2} M=15.108	{3} M=16.917	{4} M=18.304	{5} M=18.596	{6} M=21.938	{7} M=22.878	{8} M=22.574
1	{1}		0.009123	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	{2}	0.009123		0.012305	0.000002	0.000000	0.000000	0.000000	0.000000
3	{3}	0.000000	0.012305		0.321867	0.078565	0.000000	0.000000	0.000000
4	{4}	0.000000	0.000002	0.321867		0.999901	0.000000	0.000000	0.000000
5	{5}	0.000000	0.000000	0.078565	0.999901		0.000000	0.000000	0.000000
6	{6}	0.000000	0.000000	0.000000	0.000000	0.000000		0.715482	0.946859
7	{7}	0.000000	0.000000	0.000000	0.000000	0.000000	0.715482		0.999092
8	{8}	0.000000	0.000000	0.000000	0.000000	0.000000	0.946859	0.999092	

Table B4

Table B4 is a Scheffe test for the right lateral lip as measured from the right peak of Cupid's bow to the right commissure of the lip (C). This shows the statistical difference between the different age group measurements for the right lateral lip segment (R:C–P) using p-values. A significant difference between different age groups is indicated by a p-value of less than 0.05. If the p-value is greater than 0.05, then this would imply that there is very little difference in the measurements between those age groups. For example, the p-value comparing groups 6, 7 and 8 are greater than 0.71 indicating that there is no significant difference in these age groups. In other words, there has been no significant growth in the lateral lip segment between age groups 6 and 8. Similarly, there is no significant growth between age groups 3, 4 and 5.

There is however a significant increase in the growth between age groups 5 and 6 with a p-value of 0.0000. This would indicate a growth spurt of the left lateral segment between age group 5 and 6. There is also significant growth of the lateral segment between age groups 1, 2, 3 and 4 as indicated by a p-value of less than 0.05. This is shown graphically in graph B3.

Graph B3 – Right lateral lip segment for each age category



Graph B3

Graph B3 shows the growth of the right lateral segment of the upper lip. The X-axis (Age grp) represents the different age groups from age group 1 to age group 8. The Y-Axis (R:C-P) represents the lateral lip segment length as measured from the

right peak of Cupid's bow to the right commissure of the lip (C). The small square is the mean for that age group; the bigger square is the mean plus the standard error and the whiskers represent the mean plus double the standard error. If the whiskers of the different age groups are close together along the plane of the Y-axis, then there is little significant difference between the measurements in those age groups. For example, there is overlap between the squares and whiskers along the Y-axis in age groups 4 and 5 indicating that the lateral lip segment has not increased in length dramatically between these ages. Similarly, there is a marked difference between age groups 1 and 2, as well as between age groups 5 and 6 which would indicate a growth spurt in the lateral lip segment between those age groups.

Table B5: Scheffe Test; Variable: PP – C ratio

PP – C ratio : Marked differences are significant at p-values <0.0500

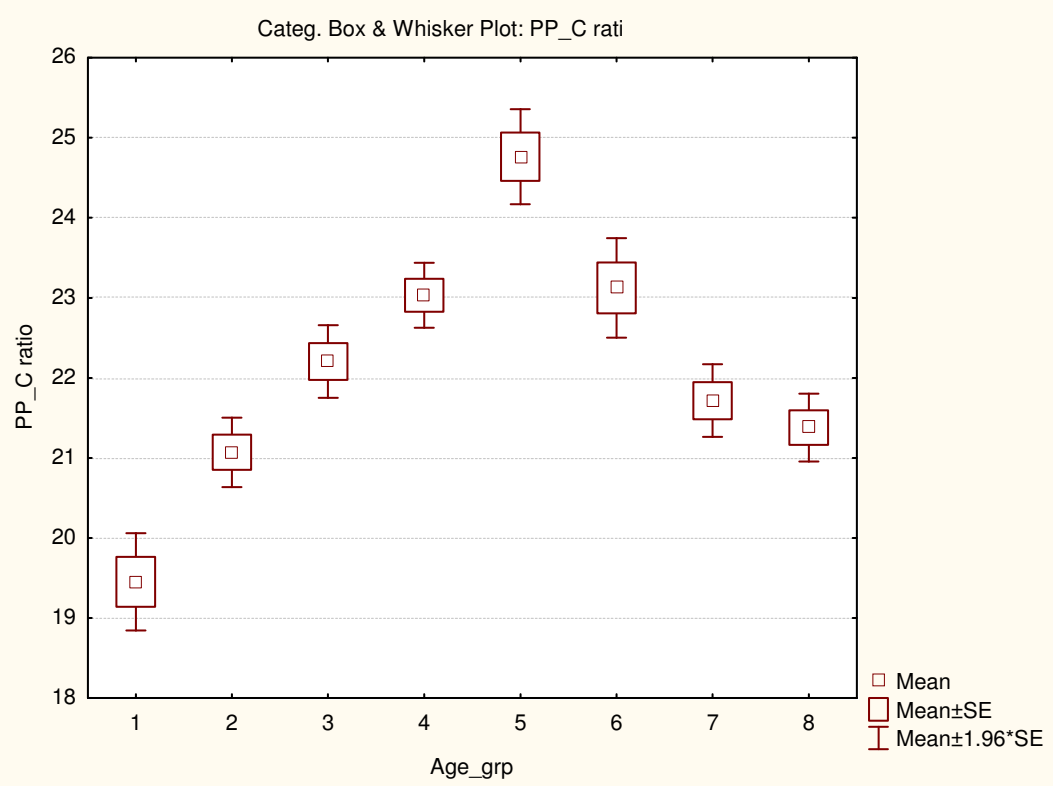
Age_gr		{1} M=19.453	{2} M=21.071	{3} M=22.204	{4} M=23.032	{5} M=24.762	{6} M=23.124	{7} M=21.717	{8} M=21.379
1	{1}		0.017777	0.000000	0.000000	0.000000	0.000000	0.000022	0.000556
2	{2}	0.017777		0.124552	0.001187	0.000000	0.000055	0.814838	0.996291
3	{3}	0.000000	0.124552		0.705315	0.000000	0.432885	0.944441	0.446203
4	{4}	0.000000	0.001187	0.705315		0.022844	1.000000	0.120479	0.009279
5	{5}	0.000000	0.000000	0.000000	0.022844		0.016801	0.000000	0.000000
6	{6}	0.000000	0.000055	0.432885	1.000000	0.016801		0.026443	0.000658
7	{7}	0.000022	0.814838	0.944441	0.120479	0.000000	0.026443		0.992245

Table B5

Table B5 is a Scheffe test for the ratios at different ages between the Cupid's bow width (PP) and the entire lip length (C) as measured from the left commissure to the right commissure. This test shows statistically significant differences between age groups 1 and 2 (p0.0177), 4 and 5 (p0.0228), 5 and 6 (p0.0168), 6 and 7 (p0.0264). These significant changes imply that there is a change in the ratio between the Cupid's bow and the total lip length. This does not mean that the ratio is necessarily increasing between those age groups as the change could be in a decreasing fashion as well. In other words, the significant change between those age groups signifies an imbalance in the growth rate between the Cupid's bow and the lateral lip segments (which contribute to the total lip length). There is no significant difference between the age groups 2 and 3 (p0.12), and 7 and 8 (p0.99). In these age

groups the ratio between the Cupid's bow and the total lip length is relatively constant which implies that the growth rate of the Cupid's bow and the lateral lip segments is similar or constant. The interesting point to note is that there is no statistical significant difference when comparing age group 2 and age group 8 (p0.99). This implies that the Cupid's bow occupies a similar percentage of the total lip length in age group 2 and age group 8.Similarly, there is no statistically significant difference between age group 3 and age group 7 (p0.94) which would have similar implications. This is shown more simply and graphically in graph B4.

Graph B4 – Cupid's Bow to lip length ratio for each category



Graph B4

Graph B4 shows the ratio between the Cupid's bow (PP) and the total lip length (C) in relation to the different age groups in this study. The X-axis (Age grp) represents the different age groups from age group 1 to age group 8. The Y-Axis (PP-C ratio) represents the proportion of the entire lip length (measured from the left to the right commissure) that is occupied by the Cupid's bow (measured from peak to peak). The small square is the mean for that age group; the bigger square is the mean plus the standard error and the whiskers represent the mean plus double the standard error. If the whiskers of the different age groups are close together along the plane of the Y-axis, then there is little significant difference between the measurements in those age groups. It is noted that there is a significant increase in the ratio between age group 1 and 2 which coincides with the growth spurt of the Cupid's bow. It can be noted that the Cupid's bow occupies roughly 19% of the total lip length in age group 1 and this jumps to above 21% in age group 2. The ratio then steadily increases between age groups 2, 3 and 4. This implies that the Cupid's bow is steadily increasing in size and occupying more of the total lip length. This does not mean that the lateral lip segments are not increasing in size but rather that the Cupid's bow is increasing in size at a rate

which is slightly faster than that of the lateral segments. A second growth spurt of the Cupid's bow is noted between age group 4 and 5 where the Cupid's bow occupies about 25% of the total lip length. It can be noted that the Cupid's bow size increases rapidly in relation to the lateral lip segments which contribute to the total lip length. The ratio rapidly decreases between age group 5 and 6 which implies that the lateral segments are now growing faster than the Cupid's bow. The ratio then steadily decreases to reach a value between 21% and 22% in adulthood. It can be noted that the Cupid's bow occupies a similar proportion of the total lip length in age group 4 and age group 6. It is important to note that the proportion of the total lip length that is occupied by the Cupid's bow increases from about one fifth (19.45%) at birth to about one quarter (24.73%) at 12 years and then decreases to about one fifth again at adulthood (21.29%).

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