A modified Mohler technique for patients with unilateral cleft lip based on geometric principles—A primary report

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A B S T R A C T

Objective: The Mohler technique is one of the most popular methods to repair unilateral cleft lip (UCL) among the modified Millard methods, but it is still imperfect. We successfully designed a modified Mohler method based on geometric principles and observed its clinical effect.

Materials and methods: Photogrammetry was performed in 56 patients who underwent UCL repair with the new technique. The symmetry ratios were assessed for sn-cphi, cphi-sbal, ch-sbal, ch-cphi, and vb preoperatively and 1 week after surgery, and were also compared with values in healthy control individuals.

Results: Preoperatively, all distances on the cleft side were shorter to different degrees. One week after surgery, results showed well-healed wounds with full, symmetric, and continuous vermilion. On the cleft side, the sn-cphi was 6.13% longer than the non-cleft, and the others were shorter (cphi-sbal: 5.904%; ch-sbal: 1.760%; ch-cphi: 6.234%). The symmetry ratios had differences of significance between preoperative values and those 1 week after surgery (p = 0.000, respectively). Moreover, the vermilion height on the cleft side was 1.026% thicker. When compared with the matched control group, with the exception of SRcphi-sbal (p = 0.072) and SRch-sbal (p = 0.139), there were significant differences (p = 0.000, respectively). All distances in the matched control group were not absolutely symmetric.

Conclusions: The modified Mohler technique seems widely applicable, marking accurate, and less flexible.

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1. Introduction

Cheiloplasty, as the sole approach of the treatment in patients with cleft lip, has been applied for more than 2000 years (Vyas and Warren, 2014). Although there are numerous techniques for unilateral cleft lip (UCL), the choice is based on the anatomical features of the cleft lip, severity of deformity, and the individual surgeon’s preference and experience (Hakim et al., 2014). Since the rotation-advancement technique for unilateral cleft lip (UCL) repair was first introduced by Millard in 1955 (Millard, 1958; Mohler, 1987; Stal et al., 2009; Vyas and Warren, 2014), this technique has quickly gained favor and popularity worldwide due to its advantages, and the indicated the validity and strength of its use in cleft lip repair (He et al., 2009; Stal et al., 2009; Vyas and Warren, 2014). However, some perceived deficiencies have been noted, and numerous researchers have attempted modifications to overcome these disadvantages (Cutting and Dayan, 2003; Demke and Tatum, 2011; Hakim et al., 2014; He et al., 2009; Kernahan and Bauer, 1983; Mohler, 1987; Mulliken and Martinez-Perez, 1999; Noordhoff, 1984; Onizuka, 1980; Saunders et al., 1986; Stal et al., 2009; Tajima, 1983). As one of the most popular methods to repair UCL deformity among the modified Millard techniques, Mohler technique has been reported since 1987 (Mohler, 1987) and has been the object of some attention (Cutting and Dayan, 2003; Mulliken and Martinez-Perez, 1999; Raposo-Amaral et al., 2012, 2014). Due to the Mohler technique’s existing shortcomings, modifications have been made by some investigators (Cutting and Dayan, 2003; Demke and Tatum, 2011; Mulliken and Martinez-Perez, 1999; Raposo-Amaral et al., 2012, 2014; Stal et al., 2009).

Until now, it has been recognized that an optimal method that is versatile and suitable for all patients with UCL deformity is not existed. In recent years, in order to design a new, widely applicable technique for UCL patients, that involves accurate marking and is
less flexible, we have carefully studied the characteristics of the Mohler technique and other Millard technique modifications, attempted to partially modify the Mohler method based on geometric principles, and completely dissected and functionally repositioned the orbicularis oris and correctly handled the red line on the vermilion. The surgical outcomes in the UCL patients 1 week after the surgery were evaluated by the photogrammetry and respectively compared with their preoperative data and those of the healthy control group. It is extremely urgent to alleviate the difficulty of UCL repair.

2. Material and methods

2.1. Patient selection and study design

A retrospective study was conducted in the patients with UCL who underwent primary cleft lip repair at our department from March 2013 to October 2014. A total of 107 patients with UCL deformity were treated. Of these, 67 patients received the modified Mohler technique, but only 56 of these met the inclusion criteria (30 males and 26 females; 24 complete and 32 incomplete cleft lips; age 2.5 months to 17 months, average 4.77 months). The inclusion criteria for the patients with UCL were as follows: 1) cleft lip (except microform); 2) same ethnic group (Han nationality) in the southwest of China; 3) without other craniofacial malformations or system diseases; 4) no orthodontic management before or after cheiloplasty; 5) no history of oral maxillofacial trauma; and 6) the primary cheiloplasty treated with the modified Mohler technique based on geometric principles by the same surgeon. Patients were excluded if their clinical data were incomplete or if photographs were not available. Postoperatively, the duration of follow-up was from 1 week to 16 months, with an average of 4.45 months.

The surgical outcomes in UCL patients at 1 week after the surgery were respectively evaluated as described below, and values were compared with those of the matched control group, using the same reference points. These infants were recruited from our department; they were of the same ethnic group and gender and of comparable age, but showed no facial impairment or previous surgical intervention.

Ethical approval was obtained from the Children's Hospital, Chongqing Medical University. Parents of the patients received an information sheet and signed a consent form.

2.2. Surgical technique

2.2.1. Operative design

The mark points and postoperative situation are shown in Fig. 1, as follows: Point 1, the peak of Cupid’s bow (cphi) on the non-cleft side. Point 2, the midpoint of Cupid’s bow. Point 3, cphi on the medial segment, and the distances between lines 1 and 2 and between lines 2 and 3 equal; L is the vertical distance between the points 1 and 3. Point 4, cphi on the lateral segment, Noordhoff point (Noordhoff, 1984), where the vermilion is widest and starts to converge medially. Point 5, subnasale (sn), the midpoint on the columellar base. Point 6, the intersection point between the philtral ridge of the non-cleft side and the arc, which is drawn by point 5 as the center of the circle and L as radius. Points 7 and 8, subalare (sbal), the most inferior point of each alar base. Points 9 and 10 at the muco-cutaneous junctions of the nostril floor of the medial and lateral cleft sides respectively in complete clefts; in incomplete clefts, the points are located on nasal basal line respectively, ensure the equal widths of nasal floor on both sides. Points 11 and 12, cheilion (ch), each labial commissure. An acute angle is formed by sequentially connecting in a straight line the points 3, 5, and 6; and two curves are formed by connecting points 3 with 9, and points 4 with 10, along the white skin roll on the cleft side respectively. The sum of distances of the straight lines 5 to 6 and 3 to 5 is the length of the philtral ridge on the cleft side. The red line (Noordhoff, 1984) is marked on the vermilion on each side. Among them, point 13 is located on the red line under point 2, line 3 to 13 is straight; and point 14 is positioned on the white skin roll on the cleft side where the dry lip disappears.

2.2.2. Incision

2.2.2.1. Non-cleft side. The technique used was as follows. Incise along the lines 6–5–3–13 and 3–9, cut through skin and subcutaneous tissue. On the incision 3–13, the orbicularis oris should be partly cut off; the musculo-mucosal flap of the vermilion is formed by a full-thickness incision perpendicular to the prolabium at point 3 and is pulled downward. The orbicularis oris is dissected and freed from mucosa along incision 3–9, as well as exposed when mucosa is turned inward to the oral side.

2.2.2.2. Cleft side. Incise along the line 10–14, which ends with a subcutaneous layer. Carefully make a penetrative incision along line 14–4, and cut off the vermilion at point 14; then a musculo-mucosal flap is formed and pulled downward. The orbicularis oris is exposed after dissection and freed from mucosa.

2.2.3. Reconstruction of oral mucosa lining at nasal base

The patients with complete cleft lip should undergo reconstruction of the nasal floor. Turn-over flaps were often used in clinic. Incise along the mucosal boundary between the oral and nasal cavity via points 9 and 10, respectively; meanwhile, incise backward along the membraneous nasal septum via point 9, and make another incision along the junction between mucosa and skin.

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Fig. 1. Schematic diagram of the incision’s design for the patients with incomplete (left) and complete (middle) unilateral cleft lip (UCL) (see text for point definition) and postoperative situation (right).
via point 10. All incision reach to the periosteal surface, and the lengths are dependent on the cleft width: the greater the width, the longer the incision. After turning the tissue flaps to the oral side, two inverted L-shaped muco-periosteal flaps are formed. An eye scissor may be used to free the nasal alar cartilage from the overlying skin and the underlying mucosa via points 9 and 10, respectively; this should extend to the nasal tip. Suture the tissue flaps appositionally, and reconstruct the oral mucosa linking at the nasal base.

2.2.4. Free and reconstruct orbicularis oris

Undermining sharply along the incisions, free the orbicularis oris muscle from the skin and mucosa. The dissection reaches to the philtral ridge on the non-cleft side, and it also extends laterally as far as the alar base on the cleft side. After the abnormal attachment of the orbicularis oris are cut down, the muscle is freed from its upturned insertion in the region of the alar base, columellar base, and alveolar cleft margin, and repositioned. On the non-cleft side, pull downward the orbicularis; a triangular space is formed; on the and alveolar cleft margin, and repositioned. On the non-cleft side, pull upturned insertion in the region of the alar base, columellar base, of the orbicularis oris are cut down, the muscle is freed from its base is also freed and advanced from the underlying maxilla after the supra-periosteal plane's undermining. To ensure the symmetry of the Cupid’s bow, the orbicularis oris should be sutured from inferior to superior, and its continuity then reconstructed.

2.2.5. Manage the skin flaps and reconstruct upper lip and nasal base

Skin flaps 3-5-6 and 5-3-9 are formed after the separation of skin and muscle. Pull point 3 downward and keep it on the same plane with point 1. Points 3 and 4 are sutured together, and then a new cphi is formed. Pull columella upward, move skin flap 5-3-9 to the non-cleft side, trim the terminal tissue according to the length of incision 5-6, close the tissue defects caused by removing flap 3-5-6 downward, and suture appositionally. To ensure that cphi on both sides lie on the same plane, close the tissue defects completely. If necessary, make an upward incision along the boundary between the mucosa and skin in the nasal cavity via point 9, to enable skin flap 5-3-9 to move freely. The nasal vestibular web is released from its posterolateral attachment to the piriform rim. To ensure the symmetry of the cphi on both sides, move the skin flap 4-10 medially and appositional suture from bottom to up. Meanwhile, on the premise of centralizing the nasal columella as well as the symmetry of both nasal bases, the tissue flaps on both cleft edges should be necessarily clipped, and then appositionally sutured to each other, and the wound on the nasal base closed completely, so the nasal base has been constructed.

2.2.6. Reparation of vermilion

On the lateral segment, make an incision along the white roll from point 14 to point 4, and draft the terminal downward. Then for a triangle muco-muscular flap from the dry vermilion and pull toward the non-cleft side, trim the size and form, and insert into the triangular space under point 3. When the red line is continuous and the vermilion symmetrical, then suture appositionally. Similarly, form another triangle muco-muscular flap of wet vermilion on the medial segment, insert it into the cleft side, and then complete the suture.

2.2.7. Deal with upper labial frenum and mucosa flap on oral cavity side

By the time the columellar location is restored, the frenulum labii superioris is sloped and bloated. To avoid relaxing the incision on the sulcus vestibularis and to ensure an esthetic appearance, smooth the frenulum and oral mucosa. Trim the frenulum and oral mucosa on both edges, and suture the wound completely in the oral cavity.

2.3. Digital photogrammetry

At preoperatively and 1 week after surgery, numerous photographs in the standard frontal view were taken for each patient using the same digital camera by the same researcher, photographs with clear anatomic landmarks and no indications of significant deformity were selected. The photogrammetry was performed on a personal computer (PC) using Digimat 4.2.0, an image analysis software developed by MedCalc Software. The measured values include the following: (Fig. 2): sn-cphi: distance between cphi and sn; ch-sbal: the distance between sbal and ipsilateral ch; ch-cphi: distance between cphi and ipsilateral ch; cphi-sbal: distance between cphi and ipsilateral sbal; vh: vermilion height.

In order to eliminate the influence of photographed parameters, symmetry ratios (SR) were selected to evaluate the outcomes, along with SR = cleft counts/non-cleft counts, in the UCL patients, and SR = shorter counts/longer counts in the control group. The estimated values include the following: SRsn-cphi: SR of sn-cphi on both sides; SRch-sbal: SR of ch-sbal on both sides; SRch-cphi: SR of ch-cphi on both sides; SRcphi-sbal: SR of cphi-sbal on both sides; SRvh: SR of vh on both sides.

2.4. Statistical analysis

All data analyses were performed with SPSS 18.0 (SPSS, Inc., Chicago, IL). A paired t-test was used to compare parameters among preoperatively and 1 week after surgery. A nonpaired t-test was employed to compare the parameters in the study group and control group. The threshold of significance was set at 0.05.

3. Results

Postoperatively, no local hematoma was apparent. We normally remove sutches on the seventh day in the absence of any infection or wound dehiscence. Patients’ wounds were healed very well with satisfactory contour, symmetric appearance, full vermilion, and continuous white roll and red line. The evaluated outcomes are shown in Table 1 and Figs. 3 and 4. Preoperative and postoperative examples of the modified technique are shown in Figs. 5–9.

Preoperatively, all distances on the cleft side were shorter to different degrees (sn-cphi: 35.45%; cphi-sbal: 14.80%; ch-sbal: 8.617%; ch-cphi: 13.307%). One week after surgery, the symmetry on both sides was obviously improved. On the cleft side, although the sn-cphi was 6.13% longer than the non-cleft, the others were shorter (cphi-sbal: 5.904%; ch-sbal: 1.760%; ch-cphi: 6.234%). The symmetry ratios of all distances were significantly different between the preoperative period and 1 week after surgery (SRsn-cphi: p = 0.000; SRcphi-sbal: p = 0.000; SRch-sbal: p = 0.000; SRch-cphi: p = 0.000). Moreover, the vermilion height on the cleft side was 1.026% thicker. When compared with the matched control group, except for SRcphi-sbal (p = 0.072) and SRch-sbal (p = 0.139), there were significant differences (SRsn-cphi: p = 0.000; SRch-cphi: p = 0.000; SRvh: p = 0.000). At the same time, in the healthy matched control group, distances were not absolutely symmetrical either.

4. Discussion

4.1. Operative design: modified Mohler technique

Identification of the anatomic landmark is the key to precise marking, and the error will affect the final surgical outcomes; a
small error or deviation may result in wide divergence. For the patient with unclear anatomic landmarks, we usually solve the problem by slightly lifting the vermilion and changing the observation angle. In all UCL techniques, the marking of the points 1-3 and 7-12 are not controversial (He et al., 2009; Kernahan and Bauer, 1983; Millard, 1960; Onizuka, 1980; Tajima, 1983; Vyas and Warren, 2014).

The marking points of the rotation incision were related mainly to the height of the philtral column on the cleft side, which was indirectly reflected with Sn-cphi. Preoperatively, we found that the asymmetry of the sn-cphi on both sides was extremely obvious (SRsn-cphi: 0.6544 ± 0.1467), and sn-cphi on the cleft side was 35.45% shorter; movement of point 3 was superior-medial. To solve this problem, the marking points were different due to differences in surgical technique (Byrd and Salomon, 2000; Cutting and Dayan, 2003; He et al., 2009; Kernahan and Bauer, 1983; Millard, 1958, 1960, 1968; Mohler, 1987; Noordhoff, 1984; Onizuka, 1980; Shi, 2001; Stal et al., 2009; Tajima, 1983) Mohler modified the Millard technique so that the curvilinear rotation incision could mimic the shape of the normal philtral ridge and extend into the columellar base. Only one incision crossed Langer’s line; and the back-cut was reached only to the middle of the philtral dimple. The C-flap was advanced into the back-cut defect and used to lengthen the shortened columella. The Millard lateral flap was not advanced to the opposite philtral ridge, instead, the lip was closed by a straight line. (Mohler, 1987) Moreover, a sharply angulated incision (near 90°) up on the columella was made instead of the Millard inverted fish hook incision, and it facilitated the closure of the C-flap without a dog ear. However, due to the back-cut, the incision was too small, and the C-flap was quite narrow and did not completely fill the entire defect. Postoperatively, the upper lip may be short; the classical Mohler’s technique would be useful only in incomplete clefts (Cutting and Dayan, 2003).

In our study, the marking points of the rotation incision were different from those of Mohler and other authors. (Cutting and Dayan, 2003; He et al., 2009; Millard, 1958, 1960, 1968; Mohler, 1987; Mulliken and Martinez-Perez, 1999; Raposo-Amaral et al., 2012, 2014; Shi, 2001) Like Onizuka (Onizuka, 1980), we mark the uppermost point of the rotation incision (point 5) on the midpoint of the columellar base. L is the vertical height difference between points 1 and 3, and the lowermost point (point 6) is related to the L value, the intersection point between the normal philtral column and the arc, at which point 5 is center and L is the radius. The rotation incision runs from point 6 upward to point 5, and turns down to point 3. The incision line is not a curve but an acute angle. (He et al., 2009) An A-flap rotates at point 5 as the rotational pivot point until points 3 and 1 are at the same horizontal level and the bilateral philtral columns are equal. The rectangular A-flap is appositionally sutured to the lateral flap. The wound is almost consistent with the normal philtral column, and then the scar can simulate the non-cleft philtral column. C-flap advances to the non-cleft side and contrapuntally sutures with the incision between the points 5 and 6 (Cutting and Dayan, 2003; Hakim et al., 2014; He et al., 2009; Millard, 1968; Mohler, 1987; Raposo-Amaral et al., 2012, 2014). This will not only close the entire medial defect, but also elongate the affected philtral column; the elongated distance is that between points 5 and 6. This acute angle rotation incision does not influence the elongated length of the affected philtral column.

Table 1
Symmetry ratios in unilateral cleft lip (UCL) patients and matched controls in upper lip.

<table>
<thead>
<tr>
<th></th>
<th>Presurgery</th>
<th>1 week postsurgery</th>
<th>Control group</th>
<th>P1</th>
<th>P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRsn-cphi</td>
<td>0.6544 ± 0.1467</td>
<td>1.0647 ± 0.0532</td>
<td>0.9853 ± 0.0848</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>SRphi-sbal</td>
<td>0.8631 ± 0.1170</td>
<td>0.9762 ± 0.0426</td>
<td>0.9868 ± 0.0955</td>
<td>0.000</td>
<td>0.072</td>
</tr>
<tr>
<td>SRch-sbal</td>
<td>0.9163 ± 0.0663</td>
<td>0.9823 ± 0.0358</td>
<td>0.9992 ± 0.1218</td>
<td>0.000</td>
<td>0.139</td>
</tr>
<tr>
<td>SRch-cphi</td>
<td>0.8716 ± 0.0855</td>
<td>0.9395 ± 0.0647</td>
<td>0.9873 ± 0.0892</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>SRvh</td>
<td>—</td>
<td>1.0112 ± 0.0204</td>
<td>0.9811 ± 0.0148</td>
<td>—</td>
<td>0.000</td>
</tr>
</tbody>
</table>

P1 reflects the symmetry of each parameter preoperatively and 1 week postsurgery. P2 reflects the symmetry of each parameter between the control individuals and UCL patients 1 week postsurgery.
(He et al., 2009), and also can widen the C-flap to successfully close the entire medial defect with a near-straight-line closure (Cutting and Dayan, 2003; He et al., 2009; Shi, 2001); then a vertical scar in the philtral dimple underneath the nasal columella is formed. The vertical incision is divided into the upper and the lower parts; only one transverse incision crosses the philtral column. However, in our clinic, no matter how complete or incomplete the clefts, once the height difference of the bilateral philtrum columns exceeds 5 mm, a simple C-flap cannot completely fill the defect. To ensure complete closure, we have adopted an upward incision, which is made along the boundary between the mucosa and skin in the nasal cavity via point 11. The C-flap extending to the inner aspect of the columella needs to be fully freed and rotated outward (Mohler, 1987). Simultaneously, the nasal vestibular web is released from its posterolateral attachment, and then turns over 90° appositional sutures to the defect at the inner aspect of the columella (He et al., 2009) It can help to close the wound, narrow the width of nasal base, and promote the ala superior-medial movement. One week after surgery, the results indicate that the SRsn-cphi was obviously improved (1.0647 ± 0.0532); it is significantly different when
compared with the preoperative anatomy and that of the matched control group ($p = 0.000$, respectively). On the cleft side, the sn-cphi was 6.13% longer. The main reason for this is that the measuring points (points 1 and 3) are pulled toward the cleft side because the ch-cphi on the lateral segment is shorter. With the elongation of the ch-cphi on the cleft side and the contraction of the scar, the symmetry of sn-cphi will be improved.

Subalare (points 9 and 10) mainly affected the ch-sbal and cphi-sbal. The ch-sbal depends on the locations of cphi and ch, but the cheilion is stationary. Preoperatively, we found that SRch-sbal was $0.9163 \pm 0.0663$. On the cleft side, ch-sbal was 8.617% shorter, and sbal moved inferior-laterally, which was caused by the abnormal attachment of the orbicularis oris and the malposition of the nasal alar cartilage and maxillary segment (in patients with cleft alve-olus); complete UCL is more obvious. The Mohler design also retained the Millard incision around the nasal base (Millard, 1958, 1960, 1968), which is quite unnecessary, since the lateral lip is essentially a straight-line repair and advancement of the lateral flap is not required (Cutting and Dayan, 2003; Mohler, 1987). We also do not use the Millard incision to avoid an unattractive horizontal scar around the alar crease (Byrd and Salomon, 2000; Cutting and Dayan, 2003; He et al., 2009; Mulliken and Martinez-Perez, 1999; Noordhoff, 1984). One week after surgery, the study indicates that the SRch-sbal has been elongated ($0.9823 \pm 0.0358$); it is significantly different when compared with the preoperative anatomy ($p = 0.000$), and there is no statistical significance with the matched control group ($p = 0.139$). On the cleft side, the ch-sbal has been elongated, which is only 1.760% shorter. Thus the new technique can result in superior-medial movement of the subalare. Possible reasons include the following: 1) widely undermining dissection around the cleft ala ensures the complete freeing of the ala and independent proper positioning; 2) the orbicularis oris on the cleft side is freed from its abnormal attachment and advanced into the medial triangular space, which is formed by the orbicularis on the non-cleft side pulling downward; 3) on the nasal base, the lateral flap is trimmed and inserted into the space that is formed by the outward movement of the skin flap from the inner nasal columnella.

The cphi on the cleft side (point 4) depends mainly on the surgeon’s understanding on the ch-cphi and sbal-cphi. It will affect ch-cphi and sbal-cphi on the cleft side, as well as the length of the advancement flap and the fullness of the vermilion, and will play an important role in the final lip symmetry. If point 4 is marked too medially, this will result in a longer ch-cphi, a shorter cphi-sbal, and...
a whistle deformity due to less vermilion on the medial element (Cutting and Dayan, 2003; Noordhoff, 1984; Raposo-Amaral et al., 2014; Vyas and Warren, 2014). Conversely, if point 4 is marked too laterally, it will provide more vermilion, a longer cphi-sbal, and a shorter ch-cphi, as well as much tension in the suture (Noordhoff, 1984; Raposo-Amaral et al., 2014; Vyas and Warren, 2014).

Like others (Mulliken and Martinez-Perez, 1999; Stal and Hollier, 2002), Mohler (Mohler, 1987) adopted the marking point similar to that in the Millard technique (Millard, 1958, 1968). It was a classic “cut as you go” technique: point 4 was marked according to the length of the rotation incision. In case of insufficient rotation, the asymmetry of cphi-sbal and the inconsistent ch-cphi cannot be resolved (Saunders et al., 1986). Some authors have found that a repaired unilateral cleft lip retains the height determined at the time of the initial repair (Gundlach et al., 1982; Saunders et al., 1986). A lip that is vertically short is far more conspicuous than one that is horizontally short (Cutting and Dayan, 2003; Noordhoff, 1984; Raposo-Amaral et al., 2014; Vyas and Warren, 2014). Meanwhile, deficiencies in lip width show a statistically significant normalisation as the patient grows (Cutting and Dayan, 2003). So, Gundlach et al. recommended that a high value be set on the symmetrical height of the upper lip when estimating the cosmetic results of lip surgery (Gundlach et al., 1982). Cutting and Dayan maintained that point 4 is determined by cphi-sbal on the non-cleft side, and that this method could keep the symmetry of cphi-sbal on both sides by sacrificing the width of the horizontal lip, as well as preventing the height from being too short on the cleft side (Cutting and Dayan, 2003; He et al., 2009; Raposo-Amaral et al., 2012, 2014). Noordhoff marked this point on the white roll where the vermilion was the widest, just before the red line converged to meet the thinning out; it also corresponded to the point at the non-cleft side philtral column base, which is known as Noordhoff’s point (Noordhoff, 1984). This can maximize the quality of incorporated labial tissues, but does not guarantee adequate vertical height. Noordhoff and others corrected this deficiency with a lower triangular flap, which resulted in a small zigzag scar just above the white roll (Cutting and Dayan, 2003; Noordhoff, 1984).

Preoperatively, we found that the differences between the cleft side and the non-cleft side of the ch-cphi and cphi-sbal were obvious (ch-cphi: 13.307%; cphi-sbal:14.80%) and that the asymmetry was noticeable (SRch-cphi: 0.8716 ± 0.0855, SRcphi-sbal: 0.8621 ± 0.1170). One week after surgery, the differences were significantly reduced (ch-cphi: 6.234%, cphi-sbal: 5.904%), and the symmetry was obviously improved (SRch-cphi: 0.9395 ± 0.0647, SRcphi-sbal: 0.9762 ± 0.0426). When compared with the preoperative anatomy, they are significantly different (p = 0.000). Nevertheless, when compared with the matched control group, except for the SRcphi-sbal (p = 0.072), SRch-cphi is significantly different (p = 0.000). We neither used the triangular flap above the white skin roll nor applied cphi-sbal on the non-cleft side to determine point 4, but directly adopted Noordhoff’s point as point 4; this has also kept the symmetry of cphi-sbal. On the cleft side, ch-cphi depends mainly on the location of point 4. Preoperatively, it was too short, with possible reasons including the following: 1) point 4 moved superior-laterally with the upturned and everted lip because of the discontinuity of the upper lip and the absence of the tissue traction, and the orbicularis oris in the lateral element runs parallel to the cleft edge and curve toward the alar base, piriform aperture, and maxillary surface (Rogers et al., 2014); and 2) it is the straight length between point 4 and the ipsilateral cheilion, rather than the arc length. Postoperatively, the ch-cphi was significantly lengthened, mainly because the lateral segment is straightened, and point 4 moved inferior-medially because of the careful repositioning of the orbicularis oris and restitution of the upper lip’s continuity. The cphi-sbal depends on point 4 and ipsilateral subalare. This technique can promote not only the subalare moving superior-medially, but also point 4’s inferior-medial movement, so that the cphi-sbal is prolonged after the surgery. During the operation, fully freeing and accurately repositioning the orbicularis oris, as well as extensive undermining dissection around the cleft ala, are very important.

4.2. Anatomy and functional reposition of musculus orbicularis oris

In UCL repair, although it is critical to completely free the aberrantly inserted orbicularis from the underlying maxilla and to carefully reapproximate it (Stal et al., 2009), the anatomy and functional repositioning of the muscle are the key to establishing a
well-shaped and functional upper lip (He et al., 2009). Mohler and others cut through the entire layer of the upper lip, including skin, muscle, and mucosa, and repaired the muscle end-to-end (Millard, 1958, 1960, 1968; Mohler, 1987; Onizuka, 1980; Stal et al., 2009). We also apply the layered incision technique used by Shi (He et al., 2009; Shi, 2001). During the operation, the orbicularis oris is freed from the alar base, columellar base, anterior nasal spine, and alveolar cleft margin, then repositioned; however, the end of the incision is not extended to the angular bisector (the lowermost point) (He et al., 2009; Shi, 2001). On the lateral segment, the orbicularis is advanced supero-medially and fills the triangular space that is formed by the orbicularis pulling downward on the medial segment (Cutting and Dayan, 2003; He et al., 2009; Stal and Hollier, 2002), and then the orbicularis orientation is corrected (Stal et al., 2009). The upper orbicularis oris is sutured and anchored to the peristeum of the anterior nasal spine (Byrd and Salomon, 2000; Stal et al., 2009); the cleft ala also is stably anchored (Stal et al., 2009; Stal and Hollier, 2002). It is bow-stringed taut to maintain tension, but is not too tight to narrow the nostril, and also maintains a natural alar-facial groove, prevents retraction of the ala, and gives the lip a natural pout (Stal et al., 2009). This is the main reason that the cleft ala was moved inwardly and upwardly. To ensure the symmetry of the Cupid's bow, the orbicularis oris should be sutured from the inferior edge to the superior extremity; the tension is gradually increased, ending with the most tension, which can give a natural pout to the lower portion of the lip (Mulliken and Martinez-Perez, 1999).

4.3. Reparation of vermillion

Vermilion repair always attracts surgeons' wide attention. The result that "a good aspect makes those bad ones be ignored" would be achieved if appropriate management were taken (Li et al., 2008). To achieve abundant and symmetric vermillion, two problems need to be solved: the continuity of the red line, and the consistent thickness. However, UCL patients often had thickness discrepancies on both sides, which is difficult to repair.

Before Noordhoff (Noordhoff, 1984) first proposed the concept of the red line, surgeons often focused on the thickness of the vermillion (Byrd and Salomon, 2000; Millard, 1958, 1960, 1968; Stal and Hollier, 2002). In 1984, Noordhoff defined the flap as an uninbend Z-plasty that is inset as a wedge into a releasing incision at the cleft muco-vermillion junction (Noordhoff, 1984). Mohler deemed that the vermillion closure should be executed in accordance with variable conditions, whether the Millard method or the Noordhoff flap is used (Mohler, 1987). In order to achieve the continuity of the red line, like other surgeons (Cutting and Dayan, 2003; He et al., 2009), we adopt the Noordhoff technique. The lateral vermillion flaps, instead of straight-line closure, may also decrease lip contraction (Demke and Tatnim, 2011). It is key that the red line be meticulously identified to keep the color match (Cutting and Dayan, 2003; Noordhoff, 1984; Raposo-Amaral et al., 2012). Simultaneously, to maintain the vermillion at a consistent thickness, we adopt the following methods: if the lateral vermillion is weak, we make a mucosal relaxing incision at the oral side of the lateral segment, then transpose a vertical mucosal flap with or without muscle from the medial cleft edge, which is based inferiorly; if the medial vermillion is weak, for a thicker muco-muscular flap on the lateral lip, the knife point is oriented slightly laterally when incising along line 14-4, and some mucosa is removed from the flap based on the length and thickness of the flap and the continuity of the red line, then filled in to the triangle space under point 3. If both are weak in vermillion, which is extremely rare, the other technique will be used (Millard, 1968). One week after surgery, patients' wounds are healed very well with full vermillion and a continuous red line, whereas the vh on the cleft side was 1.026% thicker. When compared with the matched control group, this has significant difference (p = 0.000). Nevertheless, for the control group, the vh is not absolutely symmetrical (SVrh: 0.981 ± 0.0148). Based on follow-up of patients for more than 1 year, persistent thickness of the vermillion may be related to local swelling and the longer philtral column.

5. Conclusions

This modified Mohler technique, which is based on geometric principles, is a new surgical technique for use in UCL patients. It is widely applicable, accurate, and less flexible.

References


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