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Clinical Paper
Cleft Lip and Palate

Revisiting straight-line repair in unilateral complete cleft lip: a comparison with rotation-advancement repair

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Abstract. Rotation-advancement repair (RAR) has been the most widely used technique for unilateral cleft lip repair. We recently used a straight-line repair with medial orbicularis muscle lengthening (SLR-ml) technique, based on the hypothesis that it could minimize the postoperative scar appearance without causing s short-lip deformity when muscle reorientation is performed correctly. A retrospective cohort study was conducted on unilateral complete cleft lip patients who underwent cheiloplasty between 2009 and 2017. Two cheiloplasty techniques were compared: RAR and SLR-ml. Outcomes were evaluated by assessing follow-up photographs using three methods: (1) glance impression on a five-point scale, (2) Manchester Scar Scale, and (3) indirect anthropometry. Seventy-one patients were analysed: 41 in the RAR group (28 male, 13 female) and 30 in the SLR-ml group (15 male, 15 female). The glance impression ($P = 0.506$) and Manchester Scar Scale ($P = 0.347$) scores did not differ between the groups. According to the symmetry ratio (cleft side value/non-cleft side value), vertical lip height ($P = 0.804$), horizontal lip length ($P = 0.881$), and Cupid's bow width ($P = 0.122$) did not differ significantly between the groups. The preoperative lip height discrepancy was not correlated with the postoperative vertical lip height. The SLR-ml method can be regarded as a successful tool for symmetric repair of unilateral cleft lip.

Key words: cleft lip; oral surgical procedures; anthropometry; follow-up studies; postoperative period.

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The ultimate goal of unilateral cleft lip repair is to achieve facial symmetry. Hence, for ideal results, the philtral column, Cupid's bow, and vermilion should mirror the non-cleft side. Anatomical cleft lip repair can be performed by reorienting the abnormally oriented muscle and mucocutaneous tissue. Cheiloplasty techniques have evolved through skin incision modifications to achieve an appropriate vertical lip height.

Historically, the technique for unilateral cleft lip repair has progressed from straight-line repair (SLR) to geometric-design repair[1–4] to rotation-advancement repair (RAR), with many modifications.

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One of the most widely used techniques is Millard's rotation-advancement technique, for which numerous variations have been described[5–7]. The traditional Millard's technique produces a transverse alar base scar, which is more conspicuous in Asians[8]. Moreover, it leaves a scar crossing the philtral column, which interrupts the normal anatomical boundaries and prevents mirroring of the non-cleft side philtral column[6]. Efforts have been made to improve the complex scar: transverse alar base area, three-point closure point near columella, and asymmetry to non-cleft philtral ridge[8,9]. Techniques that avoid a transverse alar base incision have been introduced[8,10–14].

Our group used the rotation-advancement technique with various rotation incisions, without a transverse alar base incision. However, the C-flap of the modified rotation-advancement method sometimes resulted in a complex scar with three-point closure points, while an unaesthetic scar at columellar base has also been noted by Mulliken and Martinez-Perez[15]. Consequently, we tried C-flap trimming during skin closure, which produced favourable outcomes. As C-flap trimming resulted in favourable outcomes, this led us to further try a straight-line incision, without creating a C-flap to make the scar even less conspicuous. It was assumed that a straight-line repair could minimize the postoperative scar when muscle reorientation is performed properly.

The purpose of this study was to evaluate the effectiveness of the SLR and to subjectively and objectively compare outcomes of two different operative techniques: RAR and SLR with medial orbicularis muscle lengthening (SLR-ml).

Patients and methods

A retrospective cohort study of patients with unilateral complete cleft lip who underwent cheiloplasty at Seoul National University Children's Hospital between January 2009 and January 2017 was conducted. RAR was performed at the beginning of the study period. The feasibility of SLR was then tested from February 2013 to March 2014. During this transition period, patients were assigned to either RAR or SLR-ml. Ultimately, the technique was changed to SLR-ml. Patients with syndromic conditions or accompanying craniofacial anomalies were excluded. Patients lacking follow-up photographs at 12–72 months postoperative were also excluded. After receiving approval from the Seoul National University Hospital Institutional Review Board (IRB No. H-1805-094-946), the patients' demographic data, medical information, and photographs were reviewed.

Operative techniques

The patients were divided into two groups according to the cheiloplasty method used:

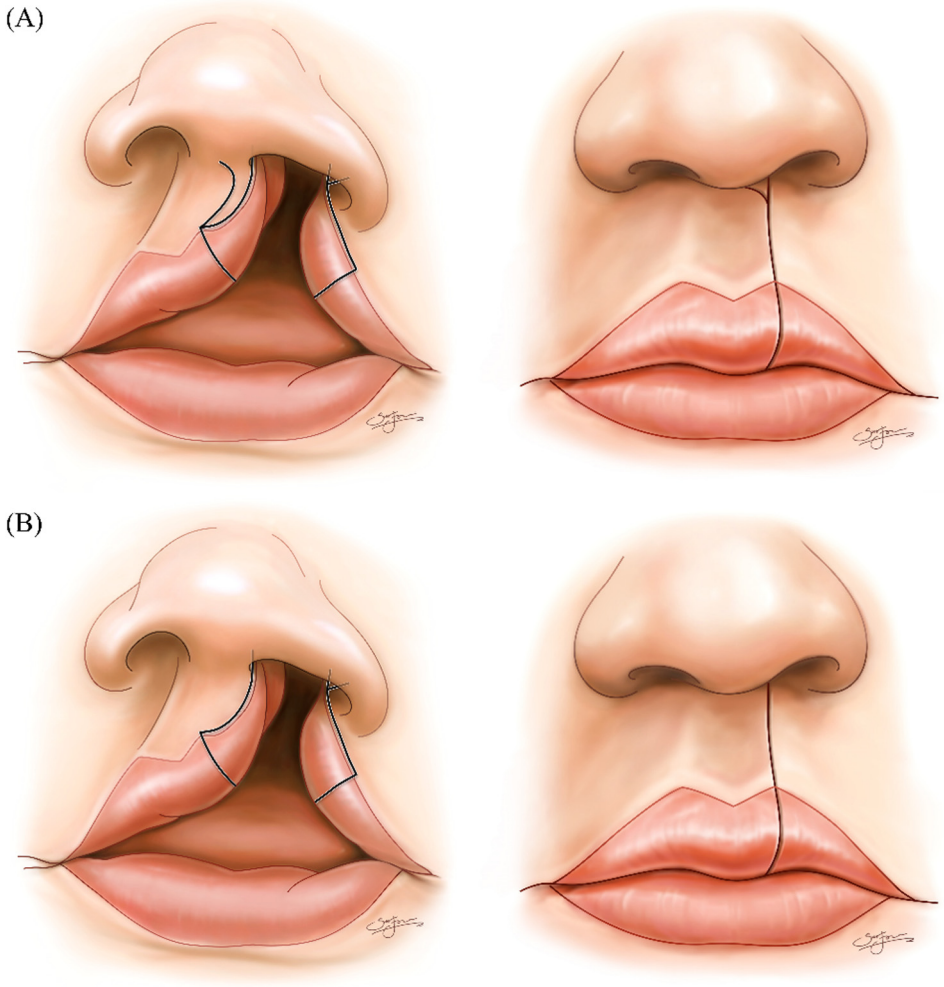

Fig. 1. Schematic illustration of the preoperative incision design and postoperative scar after (A) rotation-advancement repair, and (B) straight-line repair with medial orbicularis muscle lengthening, in unilateral complete cleft lip.

a RAR group and an SLR-ml group (Fig. 1). No patient was treated with pre-surgical orthopaedics. In both techniques, an incision was made along the cleft edge. With the RAR technique, the rotation incision ended at the midcolumellar base, similar to Noordhoff's rotation incision[16], and the transverse alar base incision of the lateral segment was eliminated. An additional small incision was made at the mucocutaneous junction of the lateral vestibule, 90 degrees from the lateral segment cleft margin to reposition the retracted alar base. This lateral vestibular incision is similar to the lateral nasal wall flap reported by Tse et al.[17]. The orbicularis oris muscle was fully detached from the alar base and the columellar base. The alar base was released widely, totally detached from the maxilla, and repositioned in the anterior and cephalic direction. The raw surface of the lateral vestibule was filled with the L-flap (lateral mucosal flap) to maintain the alar base, and the remaining L-flap and M-flap (medial mucosal flap) were used to form the nasal floor. The orbicularis oris muscle repair maintained the medially repositioned alar base. The pars peripheralis of the orbicularis oris muscle was split coronally and sutured in a vertical mattress to form a philtral column[18]. Excess skin was trimmed at the margins during skin closure, and the C-flap was also partially removed during the trimming process.

The SLR method used followed the technique developed by Kilner, which minimizes tissue sacrifice and avoids the flap on the muscle-bearing elements[19,20]. During the SLR, the medial element was dissected before the lateral element. The muscle back-cut was made at the junction between the pars marginalis and pars peripheralis[21] of the medial segment orbicularis oris muscle to elongate the medial segment. Then, a skin hook was placed at the gap formed from the muscle back-cut and was used for intraoperative lengthening of the medial element throughout the surgery. During the muscle repair, skin hook retraction was performed at both the medial and lateral segment to avoid a length discrepancy. Muscle from the lateral segment was inserted into the gap of the medial segment to prevent a short-lip and notching deformity (Fig. 2). Coronal splitting of the pars peripheralis and the vertical mattress sutures were performed as done in the RAR.

Evaluation

Perioperative and follow-up photographs taken at postoperative 12–72 months were used for evaluation. For photograph standardization, the subject was seated in a chair, with the face completely relaxed, and the subject's hair arranged to expose the ears entirely. The subject was asked to look at a point on the distant horizon to achieve a natural head position in which the Frankfurt horizontal was parallel to the floor. A camera (Nikon DSRL D100; Nikon Co., Japan) with an AF Micro Nikkor 105 mm, 1:2.8 lens (Nikon Co.) was positioned approximately 1 metre in front of the subject. Each patient was photographed in three profiles (frontal, lateral, and basal views) by one plastic surgeon. The photographs were evaluated by six doctors with sufficient experience in plastic surgery, including one professor, three fellows, and two residents. The raters were blinded to the technique used. Photographs with no information regarding the technique were distributed randomly to each rater. To determine intra-observer variability, each parameter was rated three times by each rater, on different days. The outcomes were evaluated using three methods: (1) glance impression on a five-point scale[22,23], (2) Manchester Scar Scale[24], and (3) indirect anthropometry. The average scores of each method were compared.

Glance impression was evaluated using a five-point Likert scale, rating the subjective aesthetic outcome. Raters were asked to rate each photograph from 1 to 5, with 1 representing the best result and 5 indicating the worst result.

Each scar was evaluated according to the Manchester Scar Scale[24]. The Manchester Scar Scale is reported to be appropriate for evaluating linear surgical scars, and a high correlation has been demonstrated between scores from photographs and clinical evaluations[25]. Scar colour (score range 1–4), contour (score range 1–4), distortion (score range 1–4), and whether the scar is matte or shiny (score range 1–2) were rated. An overall assessment using a visual analogue scale was also included in the Manchester Scar Scale, with 0 indicating an excellent scar and 10 representing a poor scar. The total score was the sum of all of the scores and ranged from 4 to 24.

Regarding indirect anthropometry (photogrammetry), eight landmarks were defined. Lip height was measured as the vertical lip height from subalare to Cupid's bow peak (sbal–cph). Horizontal lip length and Cupid's bow width were determined by measuring the Cupid's bow peak to cheilion distance (cph–ch) and labiale superius to Cupid's bow peak distance (cph–ls), respectively[12,26] (Fig. 3).

For each value, the symmetry ratio (SR) and symmetry index (SI) were calculated.

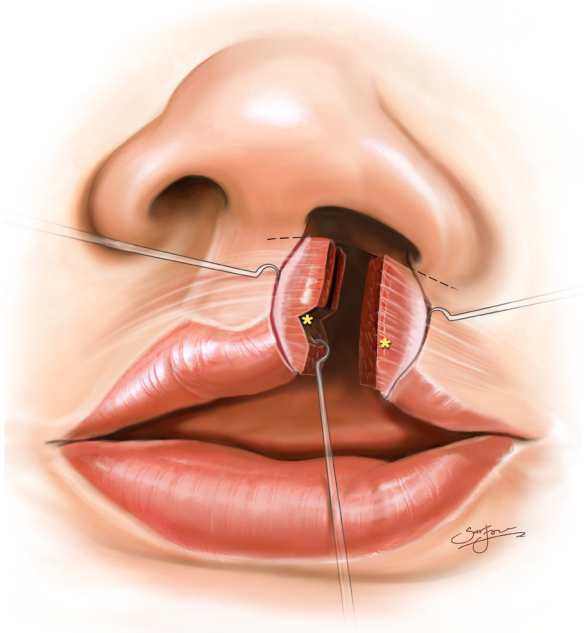

Fig. 2. Schematic illustration of muscle reconstruction during straight-line repair. The orbicularis oris muscle was fully detached from the columellar base and alar base (dotted line). A muscle back-cut was made at the junction between the pars marginalis and pars peripheralis[19,21] of the medial segment, and skin hook retraction was done for intraoperative lengthening of the medial segment. Muscle from the lateral segment was inserted into the gap to prevent a short-lip and notching deformity (*).

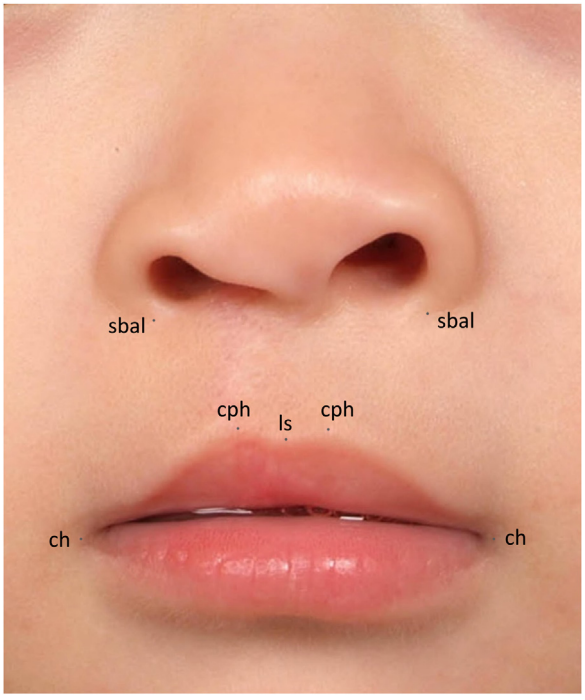

Fig. 3. Anthropometric markings for measurements. Vertical lip height (sbal–cph), horizontal lip length (cph–ch), and Cupid's bow width (cph–ls) were measured.
ch: cheilion, the point located at each labial commissure; cph: crista philtri landmark, the point on each elevated margin of the philtrum just above the vermilion line; ls: labiale superius, the midpoint of the upper vermilion line; sbal: subalare, labial insertion of the alar base.

SR[27] was calculated as the cleft side value divided by the non-cleft side value: SR = cleft side value/non-cleft side value. SI[28] was calculated as the square of the difference between 1 and SR: $SI = (1 - SR)^2$.

Statistical analysis

Each parameter was compared between the RAR and SLR-ml groups. Statistical analyses of 2 × 2 contingency tables of categorical variables were performed using Fisher's exact test. The Mann–Whitney test was used for comparisons of continuous variables. Correlations between preoperative lip height symmetry and postoperative outcomes were analysed using the linear regression test. All statistical tests were two-sided, and significance was defined as $P < 0.05$. The intra-class correlation coefficient (ICC) for inter-observer variability and the 95% confidence interval (CI) were calculated based on a mean rating of $k = 6$, absolute agreement, and two-way random-effects model. The ICC for intra-observer variability and the 95% CI were calculated based on a mean-rating of $k = 3$, absolute agreement, and two-way mixed-effects model. All analyses were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA).

Results

Patient characteristics

A total of 123 patients with unilateral complete cleft lip (with or without cleft palate/alveolus) underwent cheiloplasty during the study period. Six patients were excluded because of other concomitant anomalies. Fifteen patients were excluded because they lacked follow-up photographs and 31 patients were excluded because they only had follow-up photographs beyond postoperative 72 months. After the exclusion criteria were applied, 71 patients were included in the analysis: 41 underwent the modified RAR (RAR group; 28 male, 13 female) and 30 underwent the SLR with medial orbicularis muscle lengthening (SLR-ml group; 15 male, 15 female) (Table 1). All operations were performed by one experienced surgeon (S.K.). The mean age of the patients at the time of surgery was 3.96 months (range 2–7 months) and the mean age at the time of the follow-up photograph was 48 months (range 12–71 months).

Photogrammetric analysis

The average scores of each parameter assessed in the follow-up photographs were compared. Glance impression scores did not differ significantly between the two groups (mean score 2.53 for the RAR group and 2.16 for the SLR-ml group) ($P = 0.506$). The Manchester Scar Scale score also did not differ significantly between the two groups (mean score 10.15 for the RAR group and 10.09 for the SLR-ml group) ($P = 0.347$).

Table 1. Patient demographics.

Characteristics	Operation method		*P*-value
	Rotation-advancement repair	Straight-line repair	
Age (months), mean (range)	4 (3–7)	4 (2–6)	0.769
Cleft side			0.988
Right	11	8	
Left	30	22	
Sex			0.119
Male	28	15	
Female	13	15	
Diagnosis			0.375
Cleft lip alone	0	1	
Cleft lip and alveolus	12	11	
Cleft lip and palate	29	18	
Follow-up period postoperative (months), mean (range)	50 (12–62)	46 (12–71)	0.856

Table 2. Statistical analysis of cleft lip repair methods.

Characteristics	Operation method		*P*-value
	Rotation-advancement repair	Straight-line repair	
Glance impression on a five-point Likert scale	2.53 ± 0.85	2.16 ± 0.74	0.506
Manchester Scar Scale	10.15 ± 3.38	10.09 ± 2.73	0.347
Indirect anthropometry			
Vertical lip height (sbal–cph) SR	0.88 ± 0.72	0.91 ± 0.07	0.804
Horizontal lip length (cph–ch) SR	0.91 ± 0.13	0.89 ± 0.11	0.881
Cupid's bow width (cph–ls) SR	1.04 ± 0.17	0.99 ± 0.11	0.122

Data are mean ± standard deviation. SR, symmetry ratio (calculated as cleft side value/non-cleft side value).

Average SR values for vertical lip height (sbal–cph) were 0.88 and 0.91 in the RAR and SLR-ml groups, respectively, which were not significantly different ($P = 0.804$). Average SR values for horizontal lip length (cph–ch) were 0.91 and 0.89 for the RAR and SLR-ml groups, respectively, which were not significantly different ($P = 0.881$). Average SR values for Cupid's bow width (cph–ls) were 1.04 and 0.99 for the RAR and SLR-ml groups, respectively, which were also not significantly different ($P = 0.122$) (Table 2). Data for all patients with follow-up photographs taken after postoperative 12 months (including those with photographs obtained at >72 months) are reported in **Supplementary Material** Tables S1 and S2.

The ICC for intra-observer variability was over 0.80 and the ICC for inter-observer variability was over 0.84, indicating good reliability (**Supplementary Material** Tables S3 and S4). Representative preoperative and postoperative images are shown in Figs 4 and 5.

Correlations between the preoperative lip height (sbal–cph) SI and postoperative outcomes were analysed. Preoperative lip height SI did not affect postoperative lip height SI in either the RAR group ($P = 0.091$) or SLR-ml group ($P = 0.944$). Preoperative lip height SI also did not affect the five-point scale glance impression scores ($P = 0.976$ in the RAR group; $P = 0.470$ in the SLR-ml group) or the Manchester Scar Scale scores ($P = 0.473$ in the RAR group; $P = 0.493$ in the SLR-ml group).

Discussion

In this study, the results of rotation-advancement repair (RAR) and straight-line repair (SLR-ml) techniques were compared. The key points in the SLR-ml design included determining the midline according to the labial frenulum and setting the Cupid's bow width to no greater than 2.5 mm, to avoid a wide philtrum. The most important steps during the SLR that led to similar outcomes despite the different skin incisions included the muscle back-cut and intraoperative lengthening of the medial element. The muscle back-cut was used to elongate the muscle. The skin hook retraction, throughout the surgery, lengthened the skin and muscle of the medial element intraoperatively. In

Fig. 4. Photographs of patients who underwent straight-line repair for unilateral complete cleft lip. Male patient with a right unilateral complete cleft lip and palate: (A) before surgery (at 3 months of age) and (B) at 47 months postoperative. Male patient with a left unilateral complete cleft lip and alveolus: (C) before surgery (at 4 months of age) and (D) at 15 months postoperative.

Fig. 5. Photographs of patients who underwent rotation-advancement repair for unilateral complete cleft lip. Female patient with a right unilateral complete cleft lip and palate: (A) before surgery (at 4 months of age) and (B) at 12 months postoperative. Male patient with a right unilateral complete cleft lip and palate: (C) before surgery (at 4 months of age) and (D) at 31 months postoperative.

both techniques, the skin flaps were trimmed at the margins before skin closure. The reason that trimming was the last step in the procedure was to enhance the precision of the technique. During the RAR technique, a considerable portion of the C-flap was trimmed, and sometimes most of the C-flap was removed. A postoperative scar was prominent in cases where the C-flap remained, but not in cases where the C-flap was totally excised. Thus, the straight-line repair was readopted. Trimming of the skin was also required during the SLR-ml, especially near the nostril sill (the location where the C-flap and lateral element converge when performing the RAR).

Photographs obtained at 12–72 months after surgery were evaluated[29]. Evaluations were performed at least 12 months after surgery because the upper lip symmetry at that time is generally maintained until adulthood[30,31]. In this study, medical photographs obtained at 12–72 months after surgery were examined. The cut-off of 72 months was chosen because the insurance in South Korea covers a secondary correction of a cleft lip deformity in patients up to 6 years of age, and at Seoul National University Children's Hospital, most patients requiring a secondary correction undergo surgery when they are 6 years old. Patients undergoing a secondary correction are always photographed prior to surgery. If the study period was extended beyond 72 months, it may have induced a selection bias.

In this study, both subjective and objective outcome assessments were performed, including glance impression, which reflects overall facial aesthetics, lip measurements, and evaluation of the surgical scar. The glance impression score is associated directly with psychological well-being[22] and was found not to differ between the two methods. Objective measurements of symmetry and the scar also did not differ between the methods. Moreover, follow-up results did not vary according to the preoperative vertical lip height discrepancy, indicating that a straight-line repair is an effective method of repair for patients with considerable lip height discrepancies. This also indicates that during unilateral cleft lip repair, muscle reorientation (the 'framework') is the key step, rather than the skin incision or skin flap repositioning. Although the straight-line repair has previously exhibited several shortcomings, including short-lip deformity and blunting of the Cupid's bow[32], favourable results were achieved that were comparable to the results of the rotation-advancement method. Appropriate muscle manipulation of a unilateral complete cleft lip during SLR, including radical release of an abnormal insertion and a small incision at the junction of the pars marginalis and pars peripheralis, resulted in upper lip symmetry. We believe that SLR can be applied successfully to unilateral complete cleft lip patients by surgeons without extensive technical experience and without a complex design procedure. Many cleft surgeons have used the rotation-advancement technique for an extended period of time, and as a result tend to look only at the strengths of the technique and not the weaknesses, such as the conspicuous scar. An increase in rotation and flaps to fill the gaps following rotation lead to more scarring. Conversely, a straight-line repair results in less scarring. Furthermore, although some societies have tolerance for scars, others do not.

Nevertheless, peaking and notching deformities occurred in some patients; however, secondary deformities also occur after a rotation-advancement repair.

Minor peaking deformities after a straight-line repair were easily corrected with a small triangular flap, and the resultant scar did not differ much from the original straight-line scar. Of note, correction of the peaking deformity after rotation-advancement resulted in a new scar that crossed the original scar.

There are limitations in this study. First, because of the retrospective study design, follow-up photographs obtained during the targeted postoperative period were missing for many patients, therefore these patients were excluded. Second, the surgical technique used was not randomized but was utilized sequentially at the study institution during the study period, with a change from RAR to SLR; this may have affected the analytical power. However, it should also be noted that the surgeons who conducted these surgeries had sufficient experience before the start of the study period, and the additional experience gained during the study period is unlikely to have affected the study outcomes. Third, evaluations were performed indirectly via photographic assessment. However, photographic analysis is beneficial for the evaluation of a young population, because direct anthropometric evaluations can be difficult unless the patient is sedated. Fourth, it was not possible to identify the proportion of subjects who underwent a secondary correction because the follow-up period was not long enough for some patients, especially patients in the SLR group. Thus, the rates of a secondary deformity correction could not be compared. Lastly, focus was placed on the analysis of the upper lip, hence further studies are required to assess the effects of the technique on the nose. A prospective randomized controlled study could effectively compare the outcomes of the two techniques and could also reveal the long-term effects of the straight-line repair.

The straight-line repair method can be regarded as an effective tool for the repair of unilateral cleft lip without causing a short-lip deformity. As the skin incision type did not affect the surgical outcome, muscle reorientation appears to be more important for cleft lip repair than the skin incision.

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Competing interests

The authors declare that they have no competing interests.

Ethical approval

The study was approved by the Institutional Review Board of Seoul National University Hospital (IRB No. H-1805-094-946).

Patient consent

A waiver of informed consent was approved by the Institutional Review Board.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijom.2021.01.001.

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