Quantitative assessment of the learning curve for cleft lip repair using LC-CUSUM

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Abstract

The first step of cleft lip repair consists in a precise positioning of anatomical landmarks and in the tracing of the incisions on the patient at the beginning of the procedure. Numerous techniques are used for lip repair and the anatomy of the cleft is highly variable, making the learning of the tracing a difficult step in the training of cleft surgeons.

Here we intended to evaluate the progression in the learning of cleft lip repair tracings using a quantitative assessment of learning curves referred to as LC-CUSUM (leaning curve – cumulative sum).

We considered 8 surgery registrars (maxillofacial surgery, plastic surgery and ear, nose and throat surgery) and asked them to trace lip repair incisions on 5 cases of unilateral left cleft lip during 5 consecutive weeks. Results were compared to a reference tracing and assessed using LC-CUSUM.

We showed that despite an initial marked lack of theoretical and practical training in lip repair techniques, repeated drawings of cleft lip incisions allow to reach a satisfactory level of competence for most landmarks defining lip repair incisions. We nevertheless show that all landmarks are not understood by students with similar ease. We furthermore underline that further correlations studies are required to explore further our dataset.
Introduction

The first step of lip repair in cleft lip and palate surgery is the positioning of the anatomical landmarks and the drawing of the incisions on the patient lip under general anesthesia. An adequate drawing is crucial in obtaining quality results but landmarking can sometimes be difficult due to inter-individual variations in cleft anatomy and to the large panel of available repair techniques.

Most of French cleft teams now use a functional cleft repair protocol based on the ideas initially formulated by Jean Delaire (Smith et al. 1995). In Delaire’s approach, the primary repair involves an extensive septo-rhinoplasty and a large sub-periosteal dissection of the anterior aspect of the maxilla and the zygoma. The design of Delaire’s primary lip repair has been refined by Talmant and is based on the usual Millard rotation-advancement technique, with several modifications mostly related to the alae nasi and nostril incisions (Talmant et al. 2016a, Talmant et al. 2016b).

This method is referred to as the ‘modified Talmant primary lip repair’ is mostly taught to registrars during procedures but no formal teaching method of the lip drawing has been proposed and assessed so far, in practice or in the literature.

Here we intend to evaluate the efficiency of a simple teaching method based on repeated drawings of the modified Talmant incisions by a group of registrars and use the LC-CUSUM statistical tool (Campbell et al. 2014) to assess their learning curve.
Material and Methods

Eight registrars were involved into the study. All participants had completed at least half of their specialty training in plastic surgery, oral and maxillofacial surgery or ear, nose and throat surgery in France. Their training programs involved theoretical teaching of cleft repair and their level was assessed using a simple questionnaire (Table 1). All registrars were working in a cleft center for 4 months at the time of the beginning of the study and had been exposed to several cleft repair procedures (> 5) in theater.

Five frontal pictures of the lips from cases of left unilateral cleft lips were chosen and printed in an A4 format (Figure 1), which corresponded to a 5 x magnification. Reference drawings were provided by an experimented cleft surgeon (PC). Students were asked to draw the incisions for the 5 cases once a week for 5 consecutive weeks using tracing paper, that is a total of 5 sessions. The first session was performed without previous training. Students were instructed to read about the modified Talmant incisions during the period between the first two sessions. After the completion of the second session, students were handed the reference tracings, that they could keep until the end of the protocol, that is for sessions 3, 4 and 5. Nine landmarks (Figure 2) were selected in order to superimpose the student tracings with the reference tracings: (1) sub-nasal point; (2) midpoint of the Cupid bow; (3) lower end of the right philtral crest; (4) lower end of the right philtral crest; (5) upper end of the left philtral crest; (6)-(7)-(8) design of the A triangle (lengthening triangle) and (9) beginning of the back-cut over the orbicularis muscle.

A Cartesian coordinate system was defined on each tracing based on two perpendicular lines drawn on each cleft picture, and the distance between student and reference landmarks was measured in millimeters by three participants (ES, JBC, RHK).
The learning curves were computed using the LC-CUSUM statistical method in the R software\textsuperscript{1} according to a previously published protocol (Biau et al. 2008; Biau & Porcher 2010a; Biau & Porcher 2010b). The landmark positioning was considered satisfactory when the distance between a given landmark and the reference was $< 7$ mm on the magnified pictures, that is 1.4 mm in real size. The following curves were obtained: (1) LC-CUSUM graphs for each point combining the results from all trainees (Figure 3), (2) LC-CUSUM graphs for each trainee combining the results from all points (Figure 4) and (3) the distribution of measured distances between landmarks and references for each trainee combining the results from all cases and all points (Figure 5).

Results

Both practical and theoretical training were judged insufficient by students (Table 1). Practical training especially was nearly absent from the programs of registrars that had completed more than half of their program and were working in a pediatric maxillofacial surgery department for 4 months at the time of the study.

This lack of initial training is witnessed by the improvement of the cumulative progression after observation 5, when students were allowed to read about the Talmant technique, and after observation 10, when students were handed the reference drawings. Interestingly, the specifically good outcomes of Trainee 4 most probably refers to cheating when tracing after the reference drawings had been handed to the registrars. The progression of other trainees is satisfactory but underlines discrepancies (1) between individuals and (2) between landmarks. The landmarks located at the limit of the skin and mucosa appear to be the most difficult to locate with accuracy.

The distribution of distances for each trainee underlines the heterogeneity in learning abilities but also seems to indicate a trend for global decrease of distances with the repetition of procedures over time.
Discussion

Few studies have assessed the different learning methods for cleft lip and palate surgery. All available studies in the literature are based on the outcomes of the procedures and thus evaluate the procedures at a higher level of training (Smarius & Breugem 2015). Here we provide the first quantitative assessment of a pedagogic method based on repeated tracings of a given lip repair technique.

The anatomy of the cleft lip is three-dimensional and our assessment method was based on two-dimensional pictures. This is a major limitation in this study, and is in line with the fact that the most difficult landmarks for students were the landmarks located at the limit of skin and mucosa. These areas are regions where changes in surface curvature are of great help for the proper positioning of these landmarks. Oral 3D cameras are being used in clinical practice more and more commonly and are adapted to image capture in newborns. 3D images of cleft lips can thus be easily obtained in STL format and 3D printed with standard 3D printers. A similar study on 3D models would be more reliable by modeling more accurately the 3D specificities of cleft lip anatomy.

The use of LC-CUSUM in the quantitative assessment of learning curves has been subjected to much debate (Ail & Rhodes 2009, Biau & Weil 2011, Murgatroyd et al. 2011, Norris & McCahon 2011, Smith & Tallentire 2011). For standard repeated procedures involving a simple assessment limit (distance between student tracing and standard tracing < 1.4 mm), LC-CUSUM appears as a simple and reliable method. Its use for more multifactorial systems may be nevertheless difficult.

Finally, our dataset requires further correlation studies, as there may be progression within a single tracing session from case 1 to case 5, for a single trainee. Furthermore, there may be correlation between points that require further investigations.
Conclusion

We used a standard statistical technique in order to assess for the first time the learning curve for cleft lip tracings. We show that repeated tracing allows a partial learning of the technique, and that several anatomical landmarks seem to be more difficult to handle for registrars. Our study calls for a similar protocol using 3D models of cleft lips.
Table 1. Training items related to cleft surgery in a group of 8 maxillofacial surgery, plastic surgery and ear, nose and throat surgery French registrars. Answers were considered positive when students considered themselves that their training was sufficient for a given item.
Figure 1. Five cases of left unilateral cleft lip (first row) with the corresponding reference tracing (second row) used for assessing the tracings of the registrars.
**Figure 2.** Landmarks used for the assessment of the superimposition between the tracings from registrars and reference tracings. 1: sub-nasal point; 2: midpoint of the Cupid bow; 3: lower end of the right philtral crest; 4: lower end of the right philtrale crest; 5: upper end of the left philtrale crest; 6-7-8: design of the A triangle (lengthening triangle) and 9: beginning of the back-cut over the orbicularis muscle.
Figure 3. LC-CUSUM scores per point (points 1 to 0) showing the progression towards efficiency for each trainee.
**Figure 4.** LC-CUSUM scores per trainee (students 1 to 8) showing the progression towards efficiency for each point.
Figure 5. Distribution of distances between student landmarks and reference points for each trainee and each case.


References


