# Clinical Outcome in the Surgical Intervention of Congenital Muscular Torticollis


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Major in Medicine

Department of Medical Sciences

The Graduate School, Ajou University


Molecular Classification of

# Clinical Outcome in the Surgical Intervention of Congenital Muscular Torticollis

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-ABSTRACT-


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A number of studies have shown that facial asymmetry improves in congenital muscular torticollis (CMT) patients after surgical release. This study confirmed the improvement in facial asymmetry, and analyzed factors that affect the change of facial asymmetry in CMT patients after surgical release by using objective and quantitative methods. Facial asymmetry was analyzed in 60 CMT patients who underwent surgical release before 10 years of age. Horizontal and lower facial asymmetry angles (HFAA and LFAA) in the clinical photograph were used to measure facial asymmetry. Postoperative improvements in HFAA and LFAA were evaluated in each age group, after grouping the patients by age. Patients were divided into 2 groups according to the postoperative head tilt and functional deficit. Postoperative improvements in HFAA and LFAA were compared between 2 groups. The relationships between postoperative improvements in HFAA and LFAA and independent variables (age, follow-up period, preoperative HFAA or LFAA, postoperative head tilt, and postoperative functional deficit) were analyzed. Mean age at operation was 34.8 months (range, 6-120 mo). Horizontal facial asymmetry angle was improved significantly postoperatively in groups <5 years of age. Lower facial asymmetry angle was improved significantly postoperatively in all age groups. No significant difference was found in the postoperative improvements in HFAA and LFAA between 2 groups according to the postoperative head tilt and functional deficit. In the correlation analysis, postoperative improvements in HFAA and LFAA were proportional to the follow-up period ($r = 0.256$, $P = 0.048$) and preoperative HFAA or LFAA ($r = 0.600$, $P < 0.001$). Facial asymmetry in CMT patients can be improved in part if surgical release is performed before 10 years of age and the possibility of improvement may be different according to the area of the face. After surgical release, facial asymmetry will improve over a long period of time, and patients with more severe facial asymmetry have a better remodeling potential to achieve facial symmetry.

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Keywords: facial asymmetry; follow-up studies; surgical procedures; torticollis/congenital.

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# ABBREVIATION

CMT: congenital muscular torticollis

SCM: sternocleidomastoid

PROM: passive range of motions

HFAA: horizontal facial asymmetry angle

LFAA: lower facial asymmetry angle

HTA: head tilt angle

# I. INTRODUCTION

Congenital muscular torticollis (CMT) is caused by an idiopathic fibromatous contracture of the sternocleidomastoid (SCM) muscle that restricts movement of the neck. Contracture of the SCM muscle causes the head to turn toward the affected side and the chin to point to the opposite side. The prolonged unilateral contracture of the SCM muscle may induce craniofacial asymmetry.1–4 The characteristic appearance associated with torticollis includes deformational plagiocephaly with flattening of the contralateral side of the occiput, ipsilateral recessed orbit and zygoma, reduction in ramal height on the affected side, inferior orbital dystopia on the affected side, deviation of the nasal tip and chin point, commissural canting toward the affected side, and inferiorly and posteriorly positioned ipsilateral ear.1,4–6

Surgical release is indicated in CMT patients who do not improve after physical therapy or botulinum toxin injections or whose SCM muscle is severely fibrotic.7,8A number of studies have shown that the craniofacial asymmetry in CMT patients improves after surgical release by variable operative methods. It was, however, difficult to confirm the objective and quantitative improvement in craniofacial asymmetry because the severity of craniofacial asymmetry was evaluated on the basis of subjective and categorical values in these studies.8–14

Several studies quantitatively evaluated the craniofacial asymmetry in CMT patients using cephalometry 1,3,5,13,15,16 or three-dimensional computed tomography imaging,4 and analyzed the quantitative change in craniofacial asymmetry after surgical release 3; however, little is still known about the factors that affect the change of craniofacial asymmetry in CMT patients after surgical release.

In our previous study, we quantitatively measured the severity of preoperative craniofacial asymmetry in untreated CMT patients and showed that cranial asymmetry is already determined in those <6 months of age, although facial asymmetry is progressive if the release of contracted SCM muscle is delayed.2Hence, this study evaluated the postoperative change in facial asymmetry except cranial asymmetry, and identified the factors that affect the postoperative change of facial asymmetry in CMT patients by using objective and quantitative methods.

# II. MATERIALS AND METHODS

Three hundred nineteen CMT patients underwent complete tight fibrous band release and resection of the SCM muscle 7 at the Department of Plastic and Reconstructive Surgery of Ajou University Hospital from February 2007 to December 2012. Clinical photographs and medical records of the following patients were reviewed: patients who underwent surgical release at <10 years of age, and patients who revisited the outpatient clinic after >1 year postoperatively. Seventy-two patients were followed up for >1 year postoperatively. Eleven patients were >10 years of age at the time of operation. One patient whose clinical photograph was missing was excluded from this study. Sixty patients were evaluated in our study. The principles outlined in the Declaration of Helsinki were followed in our study.

Medical record review was performed to assess age at operation, sex, and passive range of motions (PROMs) for rotation and lateral flexion of the neck. A standardized anteroposterior photograph was taken with a digital camera wherein rotation of upper body was restricted and head was maintained naturally. Facial asymmetry and head tilt was evaluated on the photograph.

Surgical release of CMT was performed at the age of >=6 months only if the patients simultaneously met the following 2 criteria: functional limitation of the neck motion was evident because of shortening of the unilateral SCM, and the parents or the patients realized that there was no more benefit from the stretching exercises or that implementation of stretching exercises was not practically possible because of the patient's resistance to perform stretching exercises.

Postoperatively, a soft neck collar was immediately applied in the neutral neck position and was worn for 3 weeks. After the surgical wound had stabilized, an intensive physiotherapy program was undertaken to acquire full PROM of the neck by performing active strengthening exercises for 3 to 4 months.

**A. Method of Assessment**

Measurement of PROMs for rotation and lateral flexion of the neck was performed using the arthrodial protractor, with the patient in the supine position, both shoulders stabilized, and head and neck supported by the examiner over the edge of the examination couch, so that the neck was free to rotate and bend laterally.17 When a limitation during neck movement was noted, further movement was stopped and the PROM was recorded. The difference between the affected side and the normal side was recorded as the rotational or flexional deficit. The sum of rotational and flexional deficits was represented by the functional deficit

Facial asymmetry index (horizontal facial asymmetry angle [HFAA] and lower facial asymmetry angle [LFAA]) was used to measure the degree of facial asymmetry on standardized anteroposterior photographs (Fig. 1). Horizontal facial asymmetry angle is the sharp angle between the horizontal line through the bilateral exocanthions and the line through the bilateral mouth corners.16,18,19 Lower facial asymmetry angle is the angle between the line which connects nasion projection on the interexocanthal plane and gnathion, and the ideal facial midline.18 The ideal facial midline was defined as the line which is perpendicular to interexocanthal plane because the glabella, subnasale, Cupid's bow, maxillary interincisive line, and gnathion cannot be aligned perfectly in cases of asymmetry.

Head tilt angle (HTA) was used to measure the amount of head tilt on standardized anteroposterior photographs (Fig. 1). Head tilt angle is the sharp angle between the interacromial line and the ideal facial midline.

Measurement of HFAA, LFAA, and HTA was performed twice with Adobe Photoshop CS3 (Adobe Systems, San Jose, CA), and the mean value of these measurements was recorded.

**Fig. 1. Standardized anteroposterior photographs before and after operation.**

(Above) Operation was performed at the age of 10 months and the postoperative photograph was taken 25 months after the operation. Preoperative horizontal facial asymmetry angle (HFAA) = 4.1[degrees], preoperative lower facial asymmetry angle (LFAA) = 0.1[degrees]; postoperative HFAA = 2.0[degrees], postoperative LFAA = 0.3[degrees]. (Below) Operation was performed at the age of 20 months and the postoperative photograph was taken 48 months after the operation. Preoperative HFAA = 3.6[degrees], preoperative

LFAA = 1.9[degrees]; postoperative HFAA = 2.1[degrees], postoperative LFAA = 1.1[degrees]. HFAA: the sharp angle between the horizontal line through the bilateral exocanthions (red line) and the line through the bilateral mouth corners (yellow line). LFAA: the angle between the line which connects nasion projection on the interexocanthal plane and gnathion (blue line), and the ideal facial midline (green line). Head tilt angle: the sharp angle between the interacromial line (orange line) and the ideal facial midline.

**B. Assessment of Results**

The authors assumed that the age at operation, follow-up period, and preoperative severity of facial asymmetry might affect the postoperative change of facial asymmetry in CMT patients. In addition, residual limited range of motion (ROM) of the neck and residual head tilt after the operation can prevent improvement of facial asymmetry in CMT patients. To verify the above assumptions, the following tests were carried out.

First, the sample of patients was divided into 4 subgroups according to the age at the time of operation: Age Group 1, surgically treated before the age of 1 year; Age Group 2, from 1 to 3 years; Age Group 3, from 3 to 5 years; Age Group 4, from 5 to 10 years. Preoperative and postoperative facial asymmetry indexes were compared using the 2-tailed paired *t*-test. The analysis was performed separately for each age group.

Second, the patients were divided into 2 groups according to the postoperative HTA: HTA Group 1, <=5°; HTA Group 2, >5° and <=10°. Five patients with postoperative HTA >10° were excluded because we considered the operation as an incomplete release. The improvements in facial asymmetry index were compared between the 2 groups using the 2-tailed independent *t*-test.

Third, the patients were divided into 2 groups according to the postoperative rotational and flexional deficits: Functional Group 1, all of the postoperative rotational and flexional deficits <=5°; Functional Group 2, all of the postoperative rotational and flexional deficits >5° and <=10°. Five patients with postoperative rotational or flexional deficit >10° were excluded because postoperative rotational or flexional deficits >10° are classified fair or poor outcomes according to the Cheng and Tang scoring system 8. The improvements in facial asymmetry index were compared between the 2 groups using the 2-tailed independent *t*-test.

Parametric tests were used because all variables followed a normal distribution in the Shapiro-Wilk test ($P > 0.05$).

Finally, correlation and regression analyses were performed to identify the relationship between postoperative improvement in facial asymmetry index, and age at operation, follow-up period, preoperative facial asymmetry indexes, postoperative HTA, postoperative functional deficit. Regression analysis was also used to predict the effect of the above variables on improvement in facial asymmetry index.

Statistical analysis was performed with PASW Statistics 18.0 (SPSS, Chicago, IL).

# III. RESULTS

The study population composed of 60 patients (37 males and 23 females). Congenital muscular torticollis occurred on the right side in 38 cases and on the left side in 22 cases. Mean age at operation was 34.8 months (range, 6–120 mo). Mean follow-up period was 21.7 months (range, 12–53 mo). Among the 60 patients, 19 patients were included in Age Group 1, 19 in Age Group 2, 10 in Age Group 3, and 12 in Age Group 4 (Table 1).

**Table 1. Patient Characteristics**

| Age Group | Age, mo | Mean Age ± SD, mo | Follow-Up Periods, mo | Mean Follow-Up Period ± SD, mo | No. of Patients, n |
|---|---|---|---|---|---|
| 1 | ≤12 | 8.4 ± 2.2 | 12–36 | 19.6 ± 8.4 | 19 |
| 2 | 13–36 | 22.3 ± 7.0 | 12–52 | 22.5 ± 10.9 | 19 |
| 3 | 37–60 | 47.1 ± 7.5 | 12–53 | 29.4 ± 15.9 | 10 |
| 4 | ≥61 | 86.3 ± 22.3 | 12–29 | 17 ± 5.1 | 12 |
| Total | 6–120 | 34.8 ± 30.9 | 12–53 | 21.7 ± 10.8 | 60 |

In our study, the mean of HFAA and LFAA was improved significantly ($P < 0.001$) after surgical release, although facial asymmetry still persisted to some degree at the latest follow-up (Table 2) (Fig. 1) and facial asymmetry progressed a little in some patients (Fig. 2 and Fig. 3). The mean of HFAA was improved significantly postoperatively in Age Groups 1, 2, and 3 (Table 2). The mean of LFAA was improved significantly postoperatively in all age groups (Table 2).

**Table 2. Comparisons Between Preoperative and Postoperative Facial Asymmetry Index**

| Age Group | Preoperative HFAA*, ° | Postoperative HFAA, ° | Improvement in HFAA, ° | P‡ | Preoperative LFAA†, ° | Postoperative LFAA, ° | Improvement in LFAA, ° | P‡ |
|---|---|---|---|---|---|---|---|---|
| 1 | 1.83 ± 1.09 | 0.73 ± 0.74 | 1.10 ± 1.02 | <0.001 | 0.97 ± 0.88 | 0.41 ± 0.55 | 0.56 ± 0.74 | 0.004 |
| 2 | 2.04 ± 1.10 | 1.44 ± 0.93 | 0.59 ± 1.10 | 0.027 | 1.36 ± 0.83 | 0.62 ± 0.70 | 0.74 ± 0.99 | 0.005 |
| 3 | 1.85 ± 1.03 | 1.07 ± 0.54 | 0.78 ± 0.97 | 0.032 | 2.64 ± 1.17 | 1.28 ± 1.08 | 1.36 ± 1.29 | 0.008 |
| 4 | 1.86 ± 1.04 | 1.52 ± 1.17 | 0.34 ± 0.74 | 0.136 | 1.73 ± 1.22 | 1.32 ± 1.27 | 0.41 ± 0.42 | 0.009 |
| Total | 1.91 ± 1.05 | 1.17 ± 0.92 | 0.74 ± 1.00 | <0.001 | 1.52 ± 1.12 | 0.74 ± 0.85 | 0.78 ± 0.96 | <0.001 |

* HFAA, horizontal facial asymmetry angle (the sharp angle between the horizontal line through the bilateral exocanthions and the line through the bilateral mouth corners).
† LFAA, lower facial asymmetry angle (angle between the line which connects nasion projection on the interexocanthal plane and gnathion, and ideal facial midline).
‡ Paired *t*-test (2-tailed).

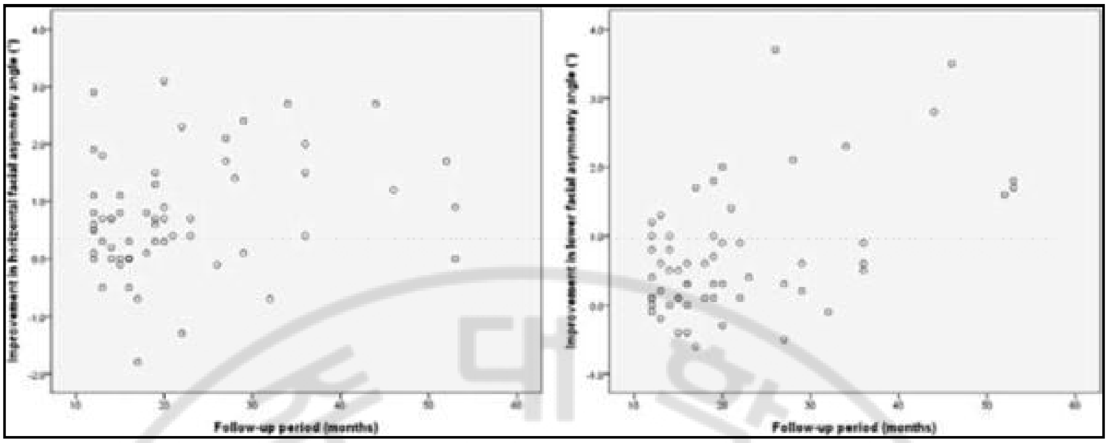


**Fig. 2. Scatter plot between improvement of facial asymmetry index and follow-up period after surgical release in congenital muscular torticollis patients.** In the correlation analysis, improvement in HFAA (Pearson correlation coefficient r = 0.256, P = 0.048) and LFAA (r = 0.461, P < 0.001) after surgical release was proportional to the follow-up period.

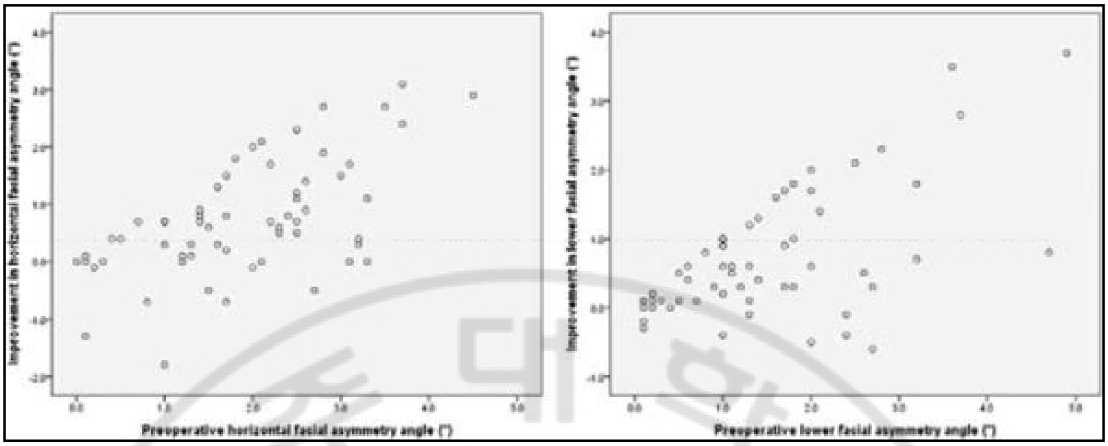


**Fig. 3. Scatter plot between improvement of facial asymmetry index and preoperative facial asymmetry index after surgical release in congenital muscular torticollis patients.** In the correlation analysis, improvement in HFAA after surgical release was proportional to the preoperative HFAA (r = 0.600, P r = 0.676, P < 0.001).

No significant difference was found in the improvements in HFAA and LFAA postoperatively between the head tilt groups 1 and 2 (Table 3) and between the functional groups 1 and 2 (Table 4). Obviously, no significant difference was found in the confounding factors, including age at operation, follow-up period, preoperative facial asymmetry index, and postoperative functional deficit or postoperative HTA in the head tilt groups and the functional groups.

**Table 3. Comparison of Improvement in Facial Asymmetry Index According to the Postoperative Head Tilt Angle**

| | HTA Group 1* | HTA Group 2† | $P$‡ |
|---|---|---|---|
| Number, n | 34 | 21 | |
| Mean HTA ± SD, ° | 1.5 ± 1.3 | 5.5 ± 1.3 | |
| Improvement in HFAA, ° | 0.75 ± 0.96 | 0.73 ± 1.11 | 0.949 |
| Improvement in LFAA, ° | 0.64 ± 0.88 | 0.95 ± 1.08 | 0.265 |

HFAA, horizontal facial asymmetry angle; HTA, head tilt angle; LFAA, lower facial asymmetry angle.

* HTA Group1: ≤5°.

† HTA Group 2: >5° and ≤10°.

‡ Independent $t$-test (2-tailed).

**Table 4. Comparison of Improvement in Facial Asymmetry Index According to the Postoperative Functional Deficit***

| | Functional Group 1† | Functional Group 2‡ | $P$§ |
|---|---|---|---|
| Number, n | 35 | 20 | |
| Mean postoperative functional deficit ± SD, ° | 1.0 ± 2.1 | 12.8 ± 4.4 | |
| Improvement in HFAA, ° | 0.885 ± 0.96 | 0.690 ± 1.09 | 0.496 |
| Improvement in LFAA, ° | 0.87 ± 1.05 | 0.62 ± 0.71 | 0.366 |

HFAA, horizontal facial asymmetry angle; LFAA, lower facial asymmetry angle.

* Functional deficit: sum of rotational and flexional deficits.

† Functional Group 1: all of the rotational and flexional deficits ≤5°.

‡ Functional Group 2: all of the rotational and flexional deficits >5° and ≤10°.

§ Independent *t*-test (2-tailed).

In the correlation analysis, the improvements in HFAA and LFAA after surgical release were proportional to the follow-up period (Table 5) (Fig. 2), and preoperative HFAA or LFAA significantly (Table 5) (Fig. 3). The improvements in HFAA and LFAA, however, were not related significantly to the age at operation, postoperative HTA, and postoperative functional deficit (Table 5). In the regression analysis, the following equation was derived:

$$\text{Improvement in HFAA} = -0.724 + 0.019 \times \text{follow-up period} + 0.554 \times \text{preoperative HFAA}$$

$$\text{Improvement in LFAA} = -0.523 + 0.025 \times \text{follow-up period} + 0.503 \times \text{preoperative LFAA}$$

**Table 5. Correlation Analyses Between Improvement in Facial Asymmetry Index, and Age at Operation, Follow-Up Period, Preoperative Facial Asymmetry Index, Postoperative Head Tilt Angle, Postoperative Functional Deficit**

| | | Age at Operation | Follow-Up Period | Preoperative HFAA or LFAA* | Postoperative HTA | Postoperative Functional Deficit |
|---|---|---|---|---|---|---|
| Improvement in HFAA coefficient | Pearson correlation | −0.188 | 0.256 | 0.600 | 0.019 | −0.111 |
| | *P* | 0.151 | 0.048 | <0.001 | 0.887 | 0.398 |
| Improvement in LFAA coefficient | Pearson correlation | 0.021 | 0.461 | 0.676 | −0.089 | −0.028 |
| | *P* | 0.878 | <0.001 | <0.001 | 0.511 | 0.837 |

HFAA, horizontal facial asymmetry angle; HTA, head tilt angle; LFAA, lower facial asymmetry angle.
*Correlation between preoperative HFAA and improvement in HFAA; correlation between preoperative LFAA and improvement in LFAA.

# IV. DISCUSSION

There have been several studies that measured facial asymmetry in CMT patients and analyzed the change in facial asymmetry quantitatively after surgical release of the contracted SCM muscle. In many studies, the cephalometric radiograph was used to quantitatively evaluate facial asymmetry in CMT patients.1,3,5,13,15,16 Lee et al 3 analyzed the objective and quantitative change of craniofacial deformity in CMT patients after surgical release, using the cephalometric radiograph and the appropriate statistical method. These studies are, however, still insufficient to thoroughly understand the change of facial asymmetry in CMT patients after surgical release. Kim et al 16 did not evaluate the postoperative change in facial asymmetry because the follow-up periods were too short to show the postoperative change in facial asymmetry. Arslan et al 13 quantitatively measured the postoperative change of facial asymmetry in CMT patients, but they failed to show a statistically significant change. Furthermore, patients in that study were >6 years, and the number of patients was 12. Moreover, other factors that may affect the postoperative change in facial asymmetry were seldom investigated except age at operation. To compensate for such limitations, we quantitatively measured facial asymmetry in CMT patients and investigated the variable factors that may affect the change in facial asymmetry after surgical release, including age at operation, follow-up period, preoperative facial asymmetry, postoperative head tilt, and postoperative functional deficit.

Anthropometric angles on a frontal digital photograph were used to measure facial asymmetry. Although cephalometric measurement has high reproducibility and is more objective than measurement using a distal photograph, it was impossible to examine patients <1 years of age holding their head in a standard position with use of a cephalostat. Anthropometric measurements were also used to evaluate facial asymmetry in many studies as a quantitative and objective method.2,18–20 A digital photograph can show facial soft tissue asymmetry and be taken repeatedly without the risk of radiation exposure. Severity of preoperative facial asymmetry, however, may be measured lower in our photograph than in a cephalometric standard position because patient's affected face is rotated to an unaffected side in our photograph.

Many studies reported about the relation between age and postoperative improvement of craniofacial asymmetry in CMT patients. Maslon et al 21 showed that facial asymmetry is more often persistent in children operated after 3 years of age. Some authors stated that complete restoration of craniofacial asymmetry can be expected in surgically treated patients <5 to 6 years of age.22–24 Based on an average follow-up period of 15 years in 55 patients, Wirth et al 9 showed that even severe facial asymmetry may resolve completely within a few years if the patient is operated before 5 years of age. Postoperative changes in craniofacial asymmetry, however, were not evaluated quantitatively in these studies. On the basis of quantitative data, Lee et al 3 recently showed that craniofacial deformity was better improved when surgical release was performed before 5 years of age in CMT patients.

In our study, horizontal facial asymmetry was improved significantly in age groups <5 years of age and lower facial asymmetry was improved significantly in all age groups after surgical release (Fig. 1) (Table 2). This result may be affected by distinguishing facial growth pattern. The facial bones grow until at different rates according to the area of the face.

The orbits, for example, have a maximum growth rate from 1 to 2 years of age and have usually attained their full adult size by the age of 7 years. The palate and maxilla have achieved two-thirds of adult size by the age of 6 years. And the mandible has later maximum growth rate between the age of 8 and 14 years than other facial areas.25 Especially, the improvement in horizontal facial asymmetry in patients <1 year of age was greater than that in older age groups, although the follow-up period was shorter (Table 2). This result may be affected by the remodeling potential of orbits. Raposo et al 26 showed that surgical correction of hypertelorbitism in patients <8 years old leads to relapse in a 30-year longitudinal study because of continued periorbital growth. Based on facial growth pattern and their study, horizontal facial asymmetry of patients >5 years of age in our study may be improved if they are followed up until completely grown. The correlation analysis did not show a significant negative linear correlation between age at operation and improvement in facial asymmetry index after surgical release (Table 5). Consequently, we noticed that facial asymmetry in CMT patients can be improved in part if surgical release is performed before 10 years of age and the possibility of improvement may be different according to the area of the face, although improvement in facial asymmetry is not inversely proportional to age at operation. The authors, however, think that it is better to perform the operation at a younger age than at an older age if patients need surgical release and their facial asymmetry is prominent because facial asymmetry in the untreated CMT patients is progressive. Definitely, additional measuring which evaluate asymmetry in different area of face has to be done to understand thoroughly improvement in facial asymmetry in CMT patients after surgical release.

It is considered that the improvement of facial asymmetry in CMT patients may be prevented by residual head tilt and residual limited ROM of the neck after surgical release. In our study, there was, however, no significant difference in the improvement in facial asymmetry after surgical release according to the postoperative HTA or the postoperative functional deficit (Tables 3 and 4). Postoperative HTA and postoperative rotational and flexional deficits, which are <=10°, are evaluated as excellent or good outcomes of the CMT operation.8,12 Correction of the head tilt and regaining the ROM of the neck is the primary goal of CMT surgery. If the primary goal of CMT surgery is achieved by obtaining excellent or good outcomes, improvement in facial asymmetry will not be prevented by residual head tilt and residual limited ROM of the neck.

Improvement of facial asymmetry in CMT patients was proportional to the follow-up period after surgical release (Table 5) (Fig. 2). In other words, facial asymmetry in CMT patients may change postoperatively until the facial skeleton grows completely; therefore, facial asymmetry should be traced until the facial skeleton grows completely. Indeed, the remodeling potential of the facial bone is greater and more long-lasting than that of the cranial bone and the growth rate differ according to the area of the face.25 Facial skeletal growth continues until the age of 18 years.11 Furthermore, a case report described that facial asymmetry was resolved almost completely postoperatively in a 10-year-old girl with CMT who was followed up for 14 years.27

There was a significant positive correlation between the preoperative severity of facial asymmetry and the improvement in facial asymmetry after surgical release (Table 5) (Fig. 3). Furthermore, in the regression analysis, improvement in facial asymmetry was more affected by preoperative facial asymmetry than other factors. This result indicated that the facial bone with more severe asymmetry has a higher remodeling potential to attain the symmetric status, if the SCM contracture is released. Indeed, this result is quite interesting. Up till now, there have been no studies showing same results as those in our report or demonstrating the effect of preoperative severity of facial asymmetry on improvement of facial asymmetry in CMT patients after surgical release. Indeed, this result might be possible because all of the patients in our study were growing and their mean age was only 34.8 months.

There are several limitations in our study. To understand the change of facial asymmetry in CMT patients after surgical release, it is essential to follow up the CMT patients until they achieve the completely grown status. We evaluated, however, the improvement of facial asymmetry in patients who were still growing. In addition, only 72 patients, among the patients, who underwent surgical release were followed up in our study. The authors tried to follow up all patients, but a number of patients did not reply to our request to visit again because they were living at distant areas, or did not notice any problems about their operation. Although this creates a selection bias, this does not contradict our results which facial asymmetry in CMT patients is improved quantitatively after surgical release because patients who were not followed up have commonly the better surgical results. Obviously, further studies are needed to confirm the results of our study. We will attempt to follow up more number of patients until they are completely grown. Despite these limitations, this study can provide help in understanding the postoperative change of facial asymmetry in CMT patients

In conclusion, we noticed that facial asymmetry in CMT patients can be improved in part if surgical release is performed before 10 years of age, and the possibility of improvement may be different according to the area of the face. The postoperative follow-up period and the severity of preoperative facial asymmetry are also important for determining the improvement in facial asymmetry postoperatively. In CMT patients, facial asymmetry will improve over a long period of time, and patients with more severe facial asymmetry have more remodeling potential to achieve facial symmetry.

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-국문요약-

# 선천성 근성 사경 환자의 수술 후 두개안면 계측치 변화의 분석

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사경 환자들의 수술적 치료 이후 안면비대칭의 호전이 보고되어 있다. 이번 연구에서는 사경 수술 결과에 대한 평가로 객관적인 계측치를 측정하고 정량적인 분석을 하여 술후 안면비대칭의 변화에 영향을 미치는 요인을 분석하였다.

10 세 이전에 사경수술을 받은 60 명의 환아를 대상으로 각 연령군에 대해 술전, 술후의 임상사진을 가지고 horizontal facial asymmetry angle(HFAA)와 lower facial asymmetry angle(LFAA)를 측정하였다. 또한 환자들은 술후 머리기울기와 기능적 결손을 기준으로 두 개의 군으로 나뉘어 술후 HFAA 와 LFAA 의 변화를 비교하였다.

HFAA 는 5 세 이하 연령군에서 의미 있는 술후 개선효과가 나타났으며, LFAA 는 모든 연령군에서 의미 있는 술후 개선효과가 나타났다. 술후 기울기와 기능적 결손에 따른 두 개의 군 사이에서 HFAA, LFAA 의 술후 변화는 의미있는 차이가 없었다.

10 세 이하의 사경 환자에게 수술적 치료이후 안면비대칭은 부위에 따라 다른 회복가능성이 확인되었다.

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핵심어: 안면비대칭, 후향적 조사, 수술적 치료, 사경