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## **Relationship between Orthodontic Treatment Plan and Goslon Yardstick Assessment in Japanese Patients with Unilateral Cleft Lip and Palate: One-stage vs. Two-stage Palatoplasty**

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### **Abstract**

The present study targeted patients with unilateral cleft lip and palate (UCLP) undergoing either one- (Wardill technique) or two-stage palatoplasty (Perko technique). Correlations between Goslon Yardstick scores and orthodontic appliances used and whether an osteotomy was performed were investigated. No differences were observed between the two types of palatoplasty in terms of Goslon Yardstick scores. A palatal expander and protraction facemask were used in Phase I of orthodontic treatment. The palatal expander was selected for most patients with UCLP in Phase I, regardless of the surgical technique used. A protraction facemask was used in patients undergoing the Wardill procedure who had a Goslon Yardstick score placing them in Group 3 or 4. In contrast, a protraction facemask was used in patients undergoing the Perko procedure who had a Goslon Yardstick score placing them in Group 4. No significant differences were observed in the Goslon Yardstick scores yielded by either type of procedure. The Goslon Yardstick score in relation to whether an osteotomy was performed in Phase II as part of orthodontic treatment was determined, focusing on the relationship between that score and the palatoplasty method used. A protraction facemask was used in patients undergoing the Perko procedure, which eliminated the need for an osteotomy at a future date. However, a protraction facemask was also used in patients undergoing the Wardill option, and those patients were likely to require an osteotomy. In other words, the results suggest that the type of palatoplasty selected will determine the effectiveness of any orthodontic appliances used.

**Key words:** Unilateral cleft lip and palate — Palatoplasty — Goslon Yardstick — Orthodontics — Protraction facemask

## Introduction

An early treatment plan for a patient with unilateral cleft palate visiting an orthodontics department typically has 2 primary goals: expanding the palate to prevent collapse of the upper dental arch and promoting anterior growth of the maxilla to treat maxillary hypoplasia, which will usually involve the use of a palatal expander and a protraction face-mask. Few studies have assessed the effectiveness of these appliances over the long term, however, and there are no criteria for appliance selection at the current point in time. Analyzing and assessing the effectiveness of these appliances in the treatment of patients with unilateral cleft palate should help to clarify the prognosis and improve surgical techniques.

On visiting the orthodontist, such a patient will have already undergone initial repair comprising one- (Wardill technique) or two-stage palatoplasty (Perko technique). One-stage palatoplasty consists of backward displacement of the palate with a mucoperiosteal flap, whereas two-stage palatoplasty involves repairing the soft palate with a buccal mucosal flap. Both types of procedure are performed at the age of 18 months. Hard palate repair is performed later, between the ages of 4 and a half to 5 years<sup>11,24</sup>). Surgery is performed in two stages because the maxilla develops to 5/6 of its size in adulthood, at around the age of 4 and a half<sup>7</sup>). Previous studies have indicated that two-stage results in better jaw development than one-stage palatoplasty<sup>3,5,18,21,22</sup>). Nevertheless, opinion is divided as to whether one- or two-stage palatoplasty is better in terms of not delaying proper pronunciation and speech<sup>2,3,15,30,31</sup>). Moreover, the timing of closure of the palate varies<sup>29</sup>).

A previous study by the current authors evaluating patients undergoing one- or two-stage palatoplasty assessed anteroposterior and lateral development of the maxilla and mandible at the start of orthodontic treatment. Although the results revealed no significant differences in anterior growth, two-stage palatoplasty did show improved results

for lateral development<sup>17</sup>).

The present study used the Goslon Yardstick to categorize dental relationships. This is based on a diagnostic model made up at the patient's initial visit to a department of orthodontics<sup>16</sup>). Here, the results of Phase I orthodontic treatment and correlations between those results and categorization of dental relationships according to the Goslon Yardstick were determined. In addition, whether not performing an osteotomy in Phase II orthodontic treatment would preclude good occlusion was investigated and the relationship between whether an osteotomy was performed and Goslon Yardstick scores analyzed. This approach was intended to reveal any differences in orthodontic treatment plans following one- or two-stage palatoplasty. Moreover, this study sought to determine whether the palatoplasty method used resulted in selection of a particular orthodontic appliance or differences in the effectiveness of that appliance.

## Materials and Methods

### 1. Overview of patient sample

All the patients in this study had unilateral cleft lip and palate (UCLP) and visited the Department of Orthodontics at the Chiba Hospital of Tokyo Dental College between 1983 and 2008. A total of 77 patients underwent the Perko procedure at the Department of Oral Surgery at this hospital, while 111 patients underwent the Wardill procedure at another hospital. In total, 188 patients were included in the analysis, excluding those who were suspected of being syndromic. The Perko group consisted of 46 men and 31 women with a mean age of 8 years and 3 months  $\pm$  1 year and 4 months. The Wardill group consisted of 69 men and 42 women with a mean age of 7 years and 8 months  $\pm$  1 year and 5 months. This study was approved by the Ethics Committee of Tokyo Dental College (Approval no.653).

## 2. Categorization of dental relationships according to Goslon Yardstick

The Goslon Yardstick is used in the longitudinal assessment of dental arch relationships throughout the development of occlusion in children with UCLP. Here, these relationships were evaluated based on the following 5 categories: Group 1: Positive overjet with average inclined or retroclined incisors with no crossbite or open-bite. Long-term outcome, excellent; Group 2: Positive overjet with average inclined or proclined incisors with unilateral crossbite or crossbite tendency with or without open-bite tendency around cleft site. Long-term outcome, good; Group 3: Edge-to-edge bite with average inclined or proclined incisors or reverse overjet with retroclined incisors. Unilateral crossbite with or without open-bite tendency around cleft site. Long-term outcome, fair; Group 4: Reverse overjet with average inclined or proclined incisors. Unilateral crossbite with or without bilateral crossbite tendency and with or without open-bite tendency around cleft site. Long-term outcome, poor; Group 5: Reverse overjet with proclined incisors, bilateral crossbite, and poor maxillary arch form and palatal vault anatomy. Long-term outcome, very poor<sup>16)</sup>.

A study model made up on the patient's initial visit was used to assign a Goslon Yardstick score of 1 to 5. The evaluators comprised 3 orthodontists certified by the Japanese Orthodontic Society at Tokyo Dental College. All the evaluators had been trained in calibrating the Goslon Yardstick as devised by Mars *et al.* All scores were assigned based on the method of Mars *et al.*<sup>16)</sup>. Mean scores were calculated for both groups of patients.

## 3. Determining relationship between treatment plan and Goslon Yardstick score

Of the 188 patients assessed in Phase I, 136 proceeded to Phase II. These patients consisted of 42 patients who underwent the Perko procedure and 94 who underwent the Wardill procedure. The treatment plan that had been implemented in Phase I was verified using medical records, and correlations between use of a palatal expander or protraction face-

mask and the Goslon Yardstick score determined. In patients proceeding to Phase II, the correlation between the number undergoing an osteotomy and the Goslon Yardstick score was determined.

## 4. Statistical analysis

A conventional Student's *t* test was used to compare the Goslon Yardstick scores of patients undergoing the Perko procedure and those undergoing the Wardill procedure; those undergoing the former were compared with those undergoing the latter in terms of whether they required a palatal expander or a protraction facemask during Phase I; both groups were also compared in terms of whether the Phase II treatment plan required an osteotomy. Comparisons were performed using Fisher's exact probability test.

## Results

### 1. Differences in Goslon Yardstick scores as result of each procedure

The study model made up on the patient's initial visit to this facility was used to assign a Goslon Yardstick score of 1 to 5. No significant differences were observed in the mean scores of the Perko ( $3.45 \pm 0.11$ ) and Wardill groups ( $3.83 \pm 0.18$ ) (Fig. 1). Patients in both groups were predominantly assigned to Group 4, with approximately 50% of the total number assigned to that group. The next largest group of patients was assigned to Group 3, with approximately 20% of the total number assigned to that group. The mean score for patients at this facility was  $3.54 \pm 0.94$  (mean  $\pm$  standard deviation) (Table 1).

Patients with UCLP who proceeded to Phase II at this facility were assessed in terms of the Goslon Yardstick score (1 to 5) they were assigned upon their initial visit. No significant differences were observed in the mean scores of the Perko ( $3.38 \pm 1.03$ ) and Wardill groups ( $3.68 \pm 0.9$ ) (Fig. 2). As at the initial visit, patients proceeding to Phase II were predominantly assigned to Group 4, with approximately 50% of the total assigned

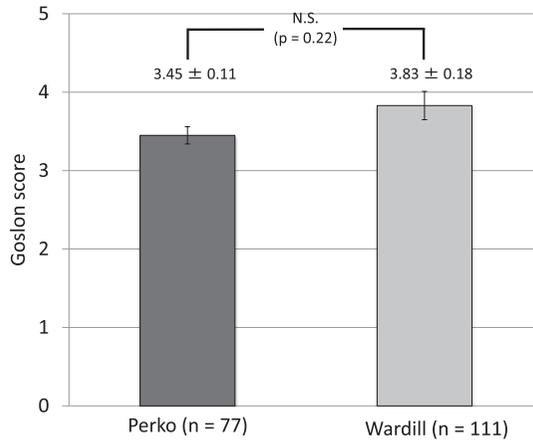


Fig. 1 Comparison of patients with UCLP in terms of Goslon Yardstick scores at start of Phase I depending on palatoplasty method used

Table 1 Breakdown of patients with UCLP in terms of Goslon Yardstick scores at start of Phase I depending on whether they underwent Perko or Wardill procedure

Goslon score		Perko (n = 77)	Wardill (n = 111)
Group 1	(excellent)	1 case (1%)	3 cases (2%)
Group 2	(good)	15 cases (19%)	13 cases (12%)
Group 3	(fair)	15 cases (19%)	22 cases (20%)
Group 4	(poor)	40 cases (53%)	60 cases (54%)
Group 5	(very poor)	6 cases (8%)	13 cases (12%)
Mean ± S.D.		3.45 ± 0.11	3.83 ± 0.18

to that group and 20% to Group 3 (Table 2). Patients proceeding from Phase I to Phase II at this facility had a mean Goslon Yardstick score of  $3.59 \pm 0.95$  (mean  $\pm$  standard deviation) upon their initial visit. In the Perko group, 54.6% proceeded from Phase I to Phase II at this facility, while 84.7% proceeded from Phase I to Phase II in the Wardill group. Overall, 72.3% of the patients proceeded from Phase I to Phase II at this facility.

## 2. Correlation between use of palatal expander and Perko or Wardill procedure

Goslon Yardstick scores were used to compare patients in each group in terms of

whether use of a palatal expander was indicated in Phase I. Of the total sample, a palatal expander was used in 91.2%, including 90.5% in the Perko group and 91.5% in the Wardill group. No significant differences were observed between the two groups in terms of the need for a palatal expander (Table 3). A comparison using Goslon Yardstick scores indicated that 100% of patients in Groups 1 and 5 needed a palatal expander, regardless of which palatoplasty procedure was used. A palatal expander was used in 80% or more of patients in Groups 2 to 4, regardless of the procedure employed (Fig. 3).

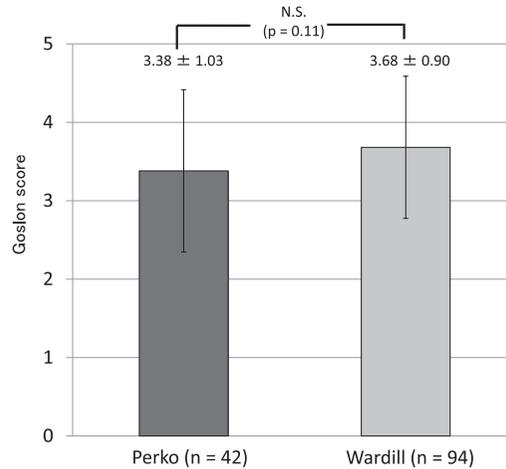


Fig. 2 Comparison of patients with UCLP proceeding to Phase II in terms of Goslon Yardstick scores at start of Phase I depending on palatoplasty method used

Table 2 Breakdown of patients with UCLP proceeding to Phase II in terms of Goslon Yardstick scores at start of Phase I depending on whether they underwent Perko or Wardill procedure

Goslon score		Perko (n = 42)	Wardill (n = 94)
Group 1	(excellent)	1 case (2%)	1 case (1%)
Group 2	(good)	10 cases (24%)	11 cases (12%)
Group 3	(fair)	7 cases (17%)	19 cases (20%)
Group 4	(poor)	20 cases (48%)	49 cases (52%)
Group 5	(very poor)	4 cases (9%)	14 cases (15%)
Mean ± S.D.		3.38 ± 1.03	3.68 ± 0.90

Table 3 Comparison of orthodontic appliance used in Phase I and whether an osteotomy was performed in Phase II depending on whether patients with UCLP underwent Perko or Wardill procedure

Need to		Yes (n)	No (n)	Fisher's exact test (p-value)		Phi
				One-side	Two-side	
Phase I Treatment						
Maxillary Expander	Perko	38	4	0.54 ns	1.00 ns	0.17
	Wardill	86	8			
Maxillary Protractor	Perko	12	30	0.22 ns	0.44 ns	0.084
	Wardill	35	59			
Phase II Treatment						
Osteotomy	Perko	1	41	0.0025 **	0.0039 **	0.242
	Wardill	20	74			

\*\* :  $p < 0.01$  ns: not significant

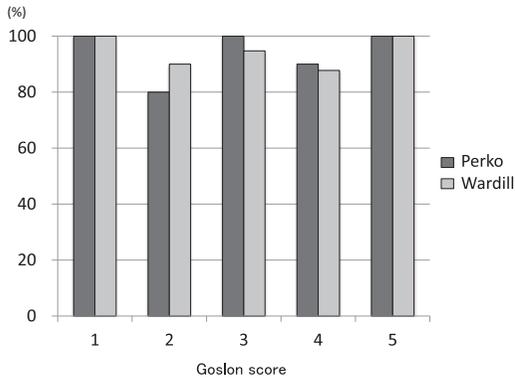


Fig. 3 Relationship between Goslon Yardstick scores depending on palatoplasty method used and selection of palatal expander in patients with UCLP

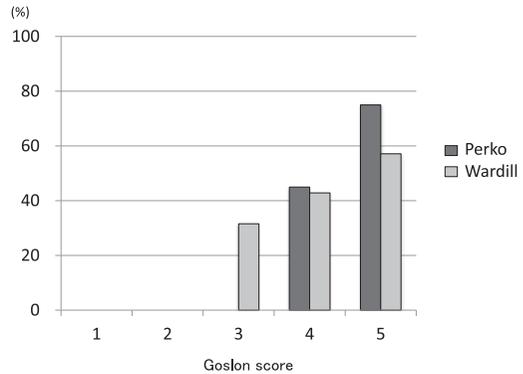


Fig. 4 Relationship between Goslon Yardstick scores depending on palatoplasty method used and selection of protraction facemask in patients with UCLP

### 3. Relationship between protraction facemask and Perko or Wardill procedure

Goslon Yardstick scores were used to compare patients undergoing the Perko or Wardill procedures in terms of whether use of a protraction facemask was indicated in Phase I. Of the total sample, a protraction facemask was used in 34.6%, including 28.6% in the Perko group and 37.2% in the Wardill group. No significant differences were observed between the two groups in terms of the need for a protraction facemask (Table 3). A comparison using Goslon Yardstick scores indicated that patients in Groups 1 to 3 undergoing the Perko procedure did not need to use a protraction facemask. Forty-five percent of patients in Group 4 and 75% percent in Group 5 needed to use a protraction facemask. Patients in Groups 1 and 2 in the Wardill group did not need to use a protraction facemask. Thirty-two percent of patients in Group 3, 43% in Group 4, and 57% in Group 5 needed to use a protraction facemask (Fig. 4).

### 4. Need for osteotomy following Perko or Wardill procedure

Among patients with UCLP treated in Phase I, 15.4% required an osteotomy in Phase II, including 2.4% of patients in the

Perko group and 21.3% in the Wardill group. Significant differences were observed between the two groups in terms of the need for an osteotomy ( $p < 0.01$ ) (Table 3). A comparison using Goslon Yardstick scores indicated that patients in Groups 1 to 4 undergoing the Perko procedure did not require an osteotomy. Twenty-five percent of patients in Group 5 required an osteotomy. Patients in Groups 1 and 2 undergoing the Wardill procedure did not require an osteotomy, but 11% in Group 3, 14% in Group 4, and 71% in Group 5 did (Fig. 5). Among patients in either group in whom a protraction facemask was used, 8% of those in the Perko and 57.1% in the Wardill group also underwent an osteotomy.

## Discussion

Patients with UCLP who visited the Department of Orthodontics at the Chiba Hospital of Tokyo Dental College for correction of malocclusion underwent either two- (the Perko procedure) or one-stage palatoplasty (the Wardill procedure). Previous studies of palatoplasty to treat UCLP have indicated that two-stage results in better jaw development than one-stage palatoplasty<sup>4,5,18,21-23,27,32</sup>. The timing of that surgery is crucial<sup>29</sup>. Any

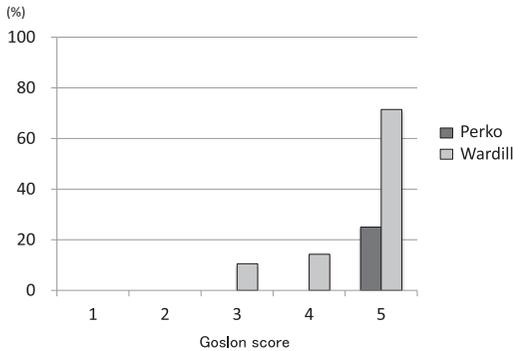


Fig. 5 Relationship between Goslon Yardstick scores depending on palatoplasty method used and selection of osteotomy in Phase II in patients with UCLP

delay in the closure of the hard palate may affect pronunciation and intelligence<sup>2,3,15,30,31</sup>. Numerous studies have cited results regarding assessment of growth and function, but a definitive answer has yet to emerge<sup>9,13,14,19,27,33</sup>. In addition, orthodontic treatment in patients with UCLP can be presumed to involve greater complexity than in those without. The present study was conducted to verify the hypothesis that postoperative orthodontic treatment leads to differences in effectiveness depending on the palatoplasty method used.

Indices to assess palatoplasty for UCLP include the Goslon Yardstick<sup>16</sup>, the 5-year-old index<sup>1</sup>, the EUROCRAN index<sup>6</sup>, the Huddart-Bodenham scoring system<sup>12</sup>, and the modified Huddart-Bodenham scoring system<sup>8,20</sup>. The present study used the Goslon Yardstick score, which is the index used most often and most widely<sup>10,16,23,25</sup>. The current results revealed only slight differences in the Goslon Yardstick scores of patients in the Perko and Wardill groups at the start of Phase I, which was in accordance with the results of earlier studies.

The Goslon Yardstick score changes when orthodontic treatment is performed, so determining the relationship between the Goslon Yardstick score during Phase I and the orthodontic appliance used is an effective way to

follow adherence to the Phase II treatment plan<sup>26</sup>. Eighty percent or more of the patients in the Wardill group proceeded to Phase II, while this was around 55% in the Perko group. No significant differences were observed in the Goslon Yardstick scores, however, which suggests that not all of the patients who proceeded to Phase II had a poor score. In addition, Goslon Yardstick scores at the start of Phase I were used to assess appliance selection in Phase I and the treatment plan used in Phase II.

Many patients with UCLP have maxillary hypoplasia and collapse of the dental arch, so the usage of a palatal expander and a protraction facemask was verified in order to identify the relationship between the extent of deformity and the Goslon Yardstick score. The results revealed that a palatal expander was used regardless of the palatoplasty method or Goslon Yardstick score. A comparison of the total sample revealed no significant differences in use of a palatal expander or a protraction facemask between the Perko and Wardill groups. Nevertheless, a protraction facemask was more likely to be used in either group if the patient had a high Goslon Yardstick score. A protraction facemask was selected for patients undergoing the Wardill procedure if they had a Goslon Yardstick score placing them in Group 3 or 4, whereas it was not selected in those undergoing the Perko procedure if they had a Goslon Yardstick score placing them in Group 3. In addition, no differences were observed in selection of a protraction facemask in either group of patients if they had a Goslon Yardstick score placing them in Group 4; a protraction facemask was selected in approximately 40% of those patients. In contrast, patients undergoing the Perko procedure who had a Goslon Yardstick score placing them in Group 5 tended to receive a protraction facemask more often than those undergoing the Wardill procedure. Although the Goslon Yardstick assigns a score based on the anteroposterior position of the anterior teeth, the aforementioned finding may be the result of orthodontists using criteria such as facial type

and overbite in deciding whether to use a protraction facemask. Thus, there may be differences between patients undergoing each type of procedure in terms of facial type or overbite. Further study is required to clarify this issue.

The biggest problem with orthodontic treatment of UCLP is whether or not an osteotomy will be required in the future. If an osteotomy is required in Phase II, treatment will be prolonged until growth of the jaw is completed. In other words, the key to success is achieving good occlusion and avoiding the need for an osteotomy. The present study focused on the relationship between the Goslon Yardstick score and osteotomy selection and palatoplasty technique. Quite a marked difference was observed between the two groups among those patients undergoing an osteotomy in Phase II. The results suggest that patients undergoing the Perko procedure are far less likely to undergo an osteotomy than those undergoing the Wardill procedure. Among patients in whom a protraction facemask was used, only 8% undergoing the Perko procedure also had to undergo an osteotomy, whereas 57.14% of those undergoing the Wardill procedure also had to undergo an osteotomy. These findings suggest that the palatoplasty method chosen can lead to differences in the effectiveness of subsequent orthodontic treatment, even if there are no differences in the Goslon Yardstick score. This finding substantiates the contention that the effectiveness of a protraction facemask varies widely, as Susami *et al.* noted<sup>28)</sup>.

For an orthodontist, predicting whether a selected appliance will be effective is crucial. The present results suggest that the Wardill procedure may not yield a satisfactory outcome, even if a protraction facemask is selected, but that the Perko option in conjunction with a protraction facemask may yield satisfactory results. Numerous studies have assessed the outcomes of surgery to treat UCLP, and basing the prognosis on the technique used is crucial. Nevertheless, to the authors' knowledge, no studies to date have investigated response to correction in the

cranio-maxillofacial region. In the present study, no major differences were observed in spontaneous growth during the period from surgery until the start of orthodontic treatment in either group of patients. The Perko procedure led to a better response to orthodontic treatment, however, than the Wardill option, indicating an improved prognosis with the former approach. Ultimately, minimally invasive orthodontic treatment that did not involve orthodontic surgery was selected.

### Conclusion

No differences were observed between the Perko and Wardill procedures in terms of Goslon Yardstick scores. A protraction facemask was used in patients undergoing the former, which eliminated the need for an osteotomy at a later stage. In contrast, a protraction facemask was also used in patients undergoing the Wardill procedure, and those patients were likely to require an osteotomy. In other words, the results suggest that the type of palatoplasty used will determine the effectiveness of orthodontic appliances.

### Conflict of Interest

The authors declare no conflict of interest related to this study.

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