

# An Overview of Indices Used to Measure Treatment Effectiveness in Patients with Cleft Lip and Palate

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## Abstract

In the contemporary era, the demand for orthodontic treatment is ever rising. Orthodontic treatment duration can range from a year to a few years. Our aim is to assess the available techniques of categorising treatment effectiveness in patients with cleft lip and palate (CLP) and to study their effect on improvement of treatment outcomes. The electronic databases including Medline-PUBMED, Science Direct, and ISI Web of Knowledge were searched from 1987 to 2013, and 40 311 relevant articles were found. Of these, we identified 22 articles including original articles as well as literature reviews. The different parameters and indices that are applied to speed-up orthodontic treatment outcomes in patients with CLP were identified as the GOSLON Yardstick, 5-year-old index, EUROCRAN index, Huddart Bodenham system, modified Huddart Bodenham system, GOAL Yardstick and, Bauru-Bilateral Cleft Lip and Palate Yardstick. This overview can create better awareness regarding the uses, advantages, and disadvantages of the different indices. It can enable better assessment and provide the impetus needed for a sustained upgrade in the standards of care for CLP in daily orthodontics.

**Keywords:** cleft lip and palate, malocclusion, treatment outcome, orthodontic index

## Introduction

There are several types of congenital craniofacial anomalies, most frequent of which are orofacial clefts that encompass the cleft lip and palate (CLP), which occurs when embryonic facial processes fail to unite (1). The complications associated with CLP are maxillary growth aberrations and high occurrence of Class III malocclusions. In children with CLP, aberrations in number, size, shape, and period of tooth formation are more common than in the non-cleft population. Orthodontic abnormalities such as crowding, rotation, and malposition of teeth are also frequent in patients with CLP (2).

'In the orthodontic context, an index is used to designate a rating or as a categorising system that assigns a numerical score or alphanumeric label to a person's occlusion' (3).

Indices have been developed for measuring the outcome of treatment more precisely in order to determine the degree of success in treating the cleft defects. An ideal measure of outcome should be easy to learn, quick to apply, reliable, and valid. There are different types of indices that assess treatment outcome in patients with CLP, such as the following: GOSLON Yardstick (4); 5-year-

old index (5); EUROCRAN index (6); Huddart Bodenham system (7), and Modified Huddart Bodenham (mHB) system (8,9).

The aim of this overview is to identify and assess the different indices that are used for categorising the treatment outcome in patients with CLP. Further, we aim to analyse, from previous studies, the ease of use of any specific index, its reliability, validity, and extent of application. Our study also investigates the compatibility of the indices with statistical scrutiny. It will benefit clinicians in the selection of a specific index for scoring the treatment outcome and enable the review of treatment options to ensure better patient care.

## Methods and Materials

In view of the importance of different indices in CLP in orthodontics, a 2-examiner-based search in literature was conducted. The electronic databases searched from 1987 to 2013 included Medline-PUBMED, Science Direct, and ISI Web of Knowledge search engines, from which 40 311 articles were included in the study initially. References of relevant articles were then searched manually and 22 articles were finally chosen, after

applying the selection criteria. The language of the articles was restricted to English. Original research articles as well as literature reviews were selected. The selection criteria included the following: appropriate quantity of subjects, quality of data assessed, type of cleft treatment, scoring system used, statistical analyses used, and the conclusions reached. The following free-text terms were used for the searches: Cleft lip and palate, Cleft indices, Crossbite index, GOSLON index, 5-year-old index, Huddart-Bodenham index, EUROCRAN index, and mBH.

## Results

The results of the literature survey for different indices in relation to CLP are shown in table 1.

## Discussion

The different types of indices along with their uses, advantages, and disadvantages are discussed below:

### *GOSLON Yardstick*

The Great Ormond Street, London and Oslo, Norway (GOSLON) Yardstick was developed for categorising the degree of malocclusion (maxillary growth) with unilateral cleft lip and palate (UCLP). The GOSLON Yardstick was introduced by Mars et al. (4). Contrasting other systems, the GOSLON Yardstick is treatment-linked (e.g. anterior crossbite with retroclination of the incisors can be corrected more easily than anterior crossbite with normal incisor inclination) and is therefore more useful than a specific anomaly-score alone. Not only the enucleating effect but also the hereditary skeletal pattern is addressed by this scoring system, as it is based on the prospects for orthodontic rectification. The system was developed for categorising the degree of malocclusion in 10-year-old children with UCLP, examined in the late mixed or early permanent dentition (4). It categorises malocclusions in patients with UCLP according to antero-posterior arch, vertical labial segment, and transverse relationships.

Uses:

- It is useful in the assessment of dental relationships in UCLP
- It has been developed for use in the late mixed and early permanent dentition
- It is valuable in predicting treatment need (orthodontic treatment, surgical treatment)

Advantages:

- The GOSLON Yardstick has proven to be able of discriminating arch relationships and interference of facial morphology outcomes between different centres (10)
- It considers clinically important variables in all 3 planes of space and permits the ranking of models in the order of difficulty to achieve a favourable outcome (11)
- It has been shown to have good inter- and intra-examiner reliability (12)
- It has been verified as an easy and practical evaluation to differentiate between the qualities of degree of malocclusion during all stages of dental development (10)
- It can predict surgical outcomes at an early age of 5 years (5)

Disadvantages:

The GOSLON Yardstick is an ordered and categorical classification, which is expected to be less powerful than an objective constant numerical measurement scale. Moreover, a continuous scale measurement more eagerly satisfies the assumptions of parametric statistical analysis (11).

The GOSLON Yardstick requires the judges to be trained in the use of this index and recalibration is necessary to assure consistency (11). The GOSLON Yardstick can only be used to score UCLP and no other cleft types (11). The validity of the GOSLON Yardstick has not been investigated and it is predicted to be difficult since it requires a cluster of adults with UCLP who have been treated by primary surgery only (11).

### *5-year-old index*

Developed by Atack et al. (5) to overcome the shortcomings of the GOSLON Yardstick, this index assesses study models of 5-year-olds. It allows surgeons to assess their treatment outcomes more precisely so that they can enhance their clinical skills.

Uses:

- It assesses dental relationships in UCLP
- It has primarily been developed for 5-year-old patients

Advantages:

- It is a more reliable tool in measuring study models of 5-year-olds than the GOSLON Yardstick (13)
- This index has been shown to have excellent intra-examiner and good inter-examiner reliability

**Table 1:** Literature survey of different indices in relation to cleft lip and palate

Author	Used Index	Outcome
Susami et al. (17)	Goslon Yardstick	Result showed good reproducibility
Hsieh et al. (18)	Goslon Yardstick	Provided reliable treatment outcome
Chan et al. (19)	Goslon Yardstick	Showed no significant group difference in the model scores of the two groups
Kajii et al. (20)	Goslon Yardstick	Showed reliable results
Morris et al. (21)	Goslon Yardstick	Provided useful baseline data
Mars et al. (22)	Goslon Yardstick	Sufficiently reliable for general use
Altalibi et al. (23)	Goslon Yardstick 5 year old index Eurocran index Huddart-Bodenham Modified Huddart- bodenham. Goal Yardstick Bauru-Bilateral Cleft Lip and Palate Yardstick	Modified Huddart –Bodenham Index equaled or outperformed the best among all indices  GOSLON Yardstick was the most commonly used index due to a longer time in use
Hathron et al. (24)	Goslon Yardstick.	Showed reliable results
Lilja et al. (25)	Goslon Yardstick	Produced the best GOSLON Yardstick ratings
Alam et al. (2)	5-year-old index Goslon Yardstick	Got satisfactory results by using 5-year- old index and Goslon Yardstick
Patel (11)	Eurocran Yardstick. Modified Huddart-Bodenham (mHB).	mHB is more reliable than Eurocran Yardstick
Flinn et al. (26)	5-year-old index	Showed excellent reliability
Dibiase et al. (27)	5-year-old index	Suitable tool for assessing the outcome of treatment
Suzuki et al. (28)	5-year-old index Huddart-Bodenham index	Occlusal outcome of cases with UCLP was fair as evaluated using the 5-year-old index
Clark et al. (29)	5-year-old index	Showed reliable results
Hathorn et al. (30)	5-year-old index	Outcomes were improved compared with previous national outcomes
Johnson et al. (31)	5-year-index	Provided a favorable outcome
Fudalj et al. (32)	Eurocran index	Showed reliable outcome
Fudalj et al. (6)	Eurocran index	Treatment outcome was reliable
Gray and Mossy et al. (2005) (16)	Modified Huddart-Bodemham system Goslon Yardstick 5-year-old index	Result showed that the modified Huddart/ Bodenham system provides an objective and reliability Assessment of maxillary arch constriction
Dobbyn et al. (2011) (17)	Modified Huddart-Bodemham system Goslon Yardstick 5-year-old index	Modified Huddart-Bodenham had been shown a much sensitive scoring system
Koshikawa-Matsuno et al. (2014) (33)	Goslon Yardstick 5-year-old index Dental model analysis	Regarding both indices, no significant differences were found. However, the dental arch width showed some significant variations

Disadvantages:

- True validation of this index is not possible and it relies on face validity
- Like the GOSLON Yardstick, the 5-year-old index is also ordinal
- This index is not versatile
- The examiners need to be calibrated; therefore, it is complex to use for scoring surgical outcomes
- It can be used only in 5-year-old patients

*EUROCRAN Yardstick*

The EUROCRAN Yardstick index was developed by the participants of the EUROCRAN project (2000–2004). This project was an extension of the EUROCLEFT project with the aim to recover research capabilities. This index was developed by using findings from the assessment of a mix of 118 cases from different European centres. A tally using the GOSLON Yardstick and the 5-year-old index had been maintained for these cases. The scores showed that only one of the cases was graded as 5, and two cases were graded as 1 by all the examiners involved in the study. Therefore, owing to the redundancy of the extremes in the scale of 1 to 5, it was decided that the grade options be reduced to 4 in the antero-posterior, vertical, and transverse dimensions, instead of the 5-grade scale. In addition, a 3-grade scale was allocated for rating the palatal form.

Thus, the EUROCRAN Yardstick is a modification of the GOSLON Yardstick and 5-year-old index, and it is again designed to assess surgical outcomes in patients with UCLP. It is applied to study models, and the major components of this index include the degree of malocclusion in the antero-posterior and vertical dimensions, and the palatal form.

Uses:

- It is useful in assessing surgical outcomes in patients with UCLP
- It can be applied to evaluate the degree of malocclusion in both antero-posterior and vertical dimensions, as well as the palatal form

Advantages:

- The supremacy of the EUROCRAN index is its validity (6)
- In order to amplify its judicious power, the index has a discrete position for degree of malocclusion and palatal morphology

- Compared to the GOSLON Yardstick, this index gives a more meticulous guide for cataloguing of treatment consequences
- It has been shown to have moderate to very good inter- and intra-examiner reliability

Disadvantages:

- It requires elaborate study
- It is difficult to apply and relies on conjectures. Consequently, there is more room for error
- There are too many details to consider, and too many preconditions and modifications
- It is more time-consuming and is more difficult to learn than the mHB
- Scoring the palatal vault is difficult
- Scoring the palatal vault is subjective (11)

*Huddart Bodenham system*

The original Huddart Bodenham scoring system was developed in 1972. It has 5 categories for scoring incisors and 3 categories for scoring canines and molars.

Uses:

- This system is used in the assessment of treatment outcomes in patients with UCLP
- It can be applied in patients with deciduous teeth
- It is useful in patients below the age of 6 years

This system was devised subsequent to evaluation of 2 other categorical indices, which were devised by Pruzansky and Aduss, and Matthews et al., both of which assess the presence and degree of crossbite, both anteriorly, and posteriorly. The study concluded that both these categorical indices were not consistent in the hands of different observers, because categories included sharp delineation and sharp delineations do not extend to occlusion. As a result, a great deal of subjective judgment was required to be employed and information regarding the indices was unreliable in different hands, since it would be very complicated to establish common assessment criteria. The paper also declared that employing two different indices, which were so different, made effective comparison of results between centres very difficult. Therefore, the authors attempted to devise an index which was numerical, gave more detailed information, and lent itself to statistical analysis (14,15).

Pruzansky and Aduss divided the occlusion into 6 categories (14):

- No crossbite
- Canine crossbite only
- Buccal crossbite only
- Anterior and buccal crossbite
- Anterior and canine crossbite
- Incisor crossbite only

In contrast, Matthews et al. divided the occlusion as follows (15):

Class A: the maxilla and the mandible are in ideal occlusion with all segments

Class B (1): the tooth bordering the cleft on the lesser segment is in lingual occlusion

Class B (2): normal occlusion of the greater segment but lingual occlusion of the lesser segment

Class B (3): the maxillary arch is perfect, but is too small

Class C: the maxilla is not only in class III position with all segments, but there is a collapse of a number of fractions of the small maxillary arch

#### *The mHB system*

This scoring system was developed after considering the above disadvantages. This system is described as 'modified' because it was developed from the original Huddart Bodenham index. Mossey et al., as well as Gray and Mossey compared this index with the GOSLON and 5-year old indices. The comparisons showed the mHB system to be more reliable, objective, sensitive, and simple to use (8,9).

Uses:

- It measures maxillary arch constriction in patients born with UCLP
- It is applicable in any type of cleft
- It measures severity of the crossbite and each maxillary tooth is scored according to its relationship with the corresponding tooth in the mandible.

Advantages:

- It is more versatile in that this index is applicable at any age after 3 years and in any type of cleft
- It is more reliable, objective, and sensitive than the GOSLON and 5-year-old Yardstick indices (9)

- It is simple to use

Disadvantages:

- It does not score for antero-posterior skeletal and vertical discrepancies, and does not take into account incisor inclinations (16)
- This scoring system has been validated on study models only

Different authors have studied different indices to obtain varying results. Susami et al. examined study models of 24 patients with UCLP, all prior to orthodontic treatment and alveolar bone grafting. The GOSLON Yardstick was used to rate the degree of malocclusion. Intra- and inter-examiner agreements estimated by weighted kappa statistics were high, indicating good reproducibility (17).

The degree of malocclusion was evaluated via the GOSLON Yardstick using intraoral dental photographs. These data suggest that intraoral dental photographs deliver a trustworthy method for rating the degree of malocclusion (18).

In another study, non-syndromic Caucasian children with UCLP were divided into 2 groups. Patients of age ranging from 5 to 10 years, who had been treated either with or without active infant orthopaedics, were selected. The study did not find any significant disparity between the two groups. While the orthopaedic group demonstrated a mean GOSLON score of 3.30, the non-orthopaedic group scored 3.21 (19).

Kajii et al. obtained all the necessary information from plaster models and assessed the same by using the GOSLON Yardstick. Their research pointed to requisite intra- and inter-examiner agreements, which was assessed using weighted kappa statistics (20).

Morris et al. assessed the maxillary growth in children born with a complete UCLP between 1983 and 1987, who had undergone primary cleft repair. The treatment outcome of this UCLP sample was then compared with the results of previously published articles. The models were assessed by using the GOSLON Yardstick. The results were of a slightly higher standard than that of previously published articles (21).

Mars et al. categorised malocclusions in patients with UCLP in a way that would symbolise the severity of malocclusion and the difficulty in correcting it. The results of the study exhibited that the GOSLON Yardstick was highly reliable and was discriminating of the quality of treatment results (22).

In a very recent literature review article about different indices that are used to measure the treatment effectiveness in patients with UCLP, the GOSLON Yardstick was stated as the most frequently used index and the mHB as the best executed index, according to the WHO criteria (23).

Hathorn et al. assessed 32 study models of patients with UCLP by using the GOSLON Yardstick. More than 50% of the sample was in the unfavourable GOSLON Groups IV and V. Hathorn et al. planned their next surgical treatment protocol based on this assessment (24).

Lilja et al. found that at 19 years of age, 85% of the patients with UCLP were in GOSLON Groups I and II, whereas 12% were assigned to Group III. Only 3% of the cases were found to be in Group IV. No dental study model was found to be in Group V. This exceptional longitudinal study of patients with UCLP demonstrates the best degrees of malocclusion thus far presented using the GOSLON Yardstick (25).

In another study, the consequence of maxillary growth by applying the 5-year-old index and GOSLON Yardstick was examined. It was found that 69% and 79% of subjects were confidential into the favourable group using the 5-year-old index and GOSLON Yardstick, respectively (20).

Patel compared the reproducibility of the mHB and EUROCRAN Yardstick. She examined 30 study models by using these two indices and the study revealed that the mHB is more reliable than the EUROCRAN Yardstick (11).

Flinn et al. analysed 118 consecutively treated 5-year-old patients with complete, non-syndromic UCLP. Average ratings of dental casts using the 5-year-old Yardstick was computed for each patient and results showed excellent reliability (26).

Dental arch dimensions of children in the primary dentition with repaired UCLP were compared with that of a non-cleft group of a similar age by Dibiase et al., using the 5-year-old index. The results showed that the 5-year-old index was an appropriate device for evaluating the effects of treatment in the primary dentition for antero-posterior and anterior transverse arch dimensions (27).

Both 5-year-old and Huddart Bodenham indices were compared by Suzuki et al. in the evaluation of dental arch dimensions. Results showed that the occlusal outcome of cases with UCLP was fair as evaluated using the 5-year-old index (28).

A similar study was carried out to evaluate the proper utilisation of the 5-year-old index. The

selected models had been made between May 1992 and April 1998, and only patients with UCLP were included in the study. Two qualified examiners measured the study models twice by using the 5-year-old index, and the index demonstrated its worth conclusively (29).

Hathorn et al. also used the 5-year-old index to gauge study models. They found an improvement in the results as compared to earlier national treatment outcomes (30).

Johnson et al. studied the grading of the degree of malocclusion in study models using the 5-year-old index. The inter- and intra-examiner agreement kappa statistics revealed good to very good agreement using this index, and this indicated a favourable outcome (31).

Fudalj et al. compared the degree of malocclusion following 1-stage and 3-stage surgical protocols for UCLP. They analysed 61 dental casts using the EUROCRAN Yardstick and the results showed reliable outcomes (32).

Fudalj et al. again studied the degree of malocclusion in 2 groups—exposed and unexposed—with UCLP that had been operated by the same surgeon. The degree of malocclusion and palatal morphology were rated separately by using the EUROCRAN Yardstick, and the treatment outcome was found to be reliable (6).

A study was undertaken to appraise the comparison of the effectiveness of the mHB system with that of the 5-year-old and GOSLON indices in subjects with UCLP. Reiterated assessment was performed after a 1-month interval by 4 appraisers. It was found that the mHB system gave a credible valuation of the maxillary arch constriction (9).

A similar study was performed using study models of subjects with UCLP from England and Scotland. All the models had been previously scored by applying the 5-year-old and GOSLON indices. The models were re-evaluated by applying the mHB system to compare the consequences and the mHB index proved to be a much more sensitive scoring system (16).

Koshikawa-Matsuno et al. recently conducted a study on 74 patients with UCLP, and they used the GOSLON Yardstick in combination with the 5-year-old index and dental model analysis. By applying weighted kappa analysis, they concluded that there was sufficient inter- and intra-examiner agreement (33).

Thus, we have reviewed different indices of diverse nature in relation to cleft lip and palate. A systematic review of such complex indices may lead to better assessment and controller bias.

## Conclusion

From this study, it can be concluded that different indices like the GOSLON Yardstick, 5-year-old Yardstick, EUROCRAN Yardstick, Huddert-Bodenham index, and mHB index are useful tools in clinical orthodontics for measuring treatment effectiveness in patients with CLP. The GOSLON Yardstick is the most commonly used index. The mHB index is encouraging in the assessment of malocclusions related to all types of CLP of all ages and in regulating the extent of outcomes in patients with CLP. The EUROCRAN Yardstick is a favourite because it can be used to evaluate the degree of malocclusion in both antero-posterior and vertical dimensions, as well as the palatal form. The 5-year-old index is the ideal index for 5-year-old patients. In orthodontics, the use of a combination of different types of indices appears to be beneficial and promising.

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