

Assessment of secondary alveolar bone grafting using two-dimensional radiographic scales: A literature review

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Abstract

Secondary alveolar bone grafting (SABG) is a key component of the multidisciplinary management of cleft lip and alveolus and cleft lip and palate. Alveolar cleft repair aims to create a bony bridge that restores maxillary continuity. The radiographic quality of this bridge is clinically important because it influences orthodontic tooth movement, prosthodontic planning, and decisions regarding possible re-grafting. Conventional X-ray images remain widely used for this assessment, and several two-dimensional scoring systems have been proposed to improve interpretive consistency. This narrative literature review critically examines the principal radiographic scales used to evaluate alveolar cleft repair and compares their core clinical properties. The Bergland scale remains the most widely recognized reference method, whereas the Enemark, Long, Kindelan, Chelsea, and SWAG scales seek to improve assessment of bone fill, morphologic detail, or applicability in mixed dentition. All of these systems rely on periapical or occlusal x-rays to estimate bony bridge height or the degree and distribution of bone fill in the cleft area.

Keywords: alveolar bone grafting, alveolar cleft, cleft palate, radiographic scales, SABG

1 Introduction

Cleft lip and palate (CLP) are among the most common congenital craniofacial anomalies. They are characterized by tissue hypoplasia and by partial or complete disruption of normal anatomical continuity in the affected region. Their management is complex, multidisciplinary, and prolonged, often extending over many years.

Secondary alveolar bone grafting, or SABG, is usually performed during mixed dentition. Boyne and Sands originally described this technique in 1972 [1]. According to timing, the procedure is classified as early secondary grafting, performed before eruption of the permanent lateral incisor, or late secondary grafting, performed after the canine root has developed to approximately one-half to one-third of its length. The most favourable outcomes are reported when the grafted bone is functionally loaded and the lateral incisor or canine erupts through the graft [2, 3, 4].

Autogenous bone grafting aims to stabilize the dental arch by closing the oronasal fistula and restoring anatomical continuity in the maxillary alveolar process, particularly in bilateral clefts. In addition, the transplanted bone provides bony support to the nasal alae and can improve nasal symmetry [1].

The radiographic result of SABG directly influences subsequent treatment planning. When a tooth is absent in the cleft region, graft quality helps determine whether space closure or prosthetic replacement is more appropriate. Conventional two-dimensional X-ray images have historically been used for this assessment, and Abyholm et al. [5] proposed the first formal scale for evaluating SABG outcomes, establishing the basis for later 2D systems.

Although three-dimensional X-ray techniques now permit more detailed qualitative and quantitative assessment, plain radiographs remain widely used because they are familiar, accessible, and embedded in much of the historical outcome literature.

The purpose of this narrative review is to compare the principal radiographic success scales proposed for alveolar cleft repair and to examine the practical qualities that make a scale clinically useful, including clarity, reproducibility, anatomic completeness, and applicability across stages of dentition.

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2 Scales based on plain radiographs

Beginning in the 1980s, several radiographic scales were introduced on the basis of measurements derived from conventional intraoral x-rays [5, 6, 7]. These systems became widely adopted and remain the most frequently cited two-dimensional methods for assessing the outcome of alveolar cleft repair [8, 9, 10]. Because they differ in simplicity, anatomic coverage, and timing of use, their strengths and limitations merit direct comparison. The following subsections review the principal plain-radiograph-based scales:

2.1 Radiographic assessment by Abyholm et al. [5]

Abyholm et al. [5] proposed the first formal grading system for assessing SABG outcomes on two-dimensional radiographs, using periapical imaging. The four-point scale classifies grade I as approximately normal interdental septum height, grade II as at least 3/4 of normal height, grade III as less than 3/4 of normal height, and failure as the absence of a continuous bony bridge. Although relatively simple, it established the conceptual framework for later and more detailed classifications.

2.2 Bergland scale

Its simplicity and direct clinical applicability have kept it the best-known scale in routine use. The system first appeared in the preliminary University of Oslo study by Abyholm, Bergland, and Semb [5], and was later popularized as the Oslo grading system by Bergland et al. [11]. Its clinical utility was further illustrated in a larger 1986 report [12]. The scale measures the height of the interdental bony septum in the repaired cleft region relative to the cervical level of the adjacent teeth (canine and lateral or central incisor) on periapical or occlusal x-rays. After assessment, each case is assigned to a single semiquantitative category, as shown in Table 1. A threshold of 75% of normal bone height (types I and II) is generally regarded as the minimum for a clinically satisfactory outcome, because that level is expected to provide adequate periodontal support during orthodontic tooth movement [12].

Despite its widespread use, the Bergland scale has important limitations. First, it is intended for use after eruption or orthodontic guidance of a tooth into the cleft region and therefore is not ideally suited to mixed dentition or to cases in which a tooth is absent within the cleft [13]. Second, it does not directly assess bone in the most apical part of the cleft. Consequently, a case may be classified as successful on the basis of a relatively normal cervical bone level even when there is no continuous bony bridge in the middle or apical region and the nasal floor remains inadequately supported [13]. To address this limitation, modifications that incorporate apical assessment were proposed by Hynes and Earley in 2003 [14] and by Semb et al. [15], but these variants have not achieved the same level of acceptance (Table 1).

Table 1: Bergland scale

Type I and II being satisfactory outcomes and Types III and IV being unsatisfactory.
Type I: Interdental septum height is almost normal (< 25% of bone resorption).
Type II: Interdental septum height is equal to or greater than 1/4 of the normal height (bone resorption 25% – 50%).
Type III: Interdental septum height is less than 1/4 of the normal height (bone resorption 50% – 75%).
Type IV: Bone graft failure; no continuous bony bridge is visible across the cleft (bone resorption \geq 75%).

2.3 Enemark scale

Enemark et al. [6] proposed a scale that closely parallels the Bergland system. Like Bergland, it assumes that orthodontic tooth movement has been completed and compares the bone level in the repaired cleft with the cervical level of the adjacent teeth. Its main distinction is that it divides the range of bone height into

evenly distributed categories rather than using Bergland's asymmetrical thresholding. Table 2 summarizes the categories. Although commonly cited, some authors [16, 17, 18] describe the Enemark scale under other names or treat it as a modification of the Abyholm-Bergland approach. In addition, several investigators [16, 17, 18] have used 50% of normal height (scores 1 and 2) as the practical threshold for a successful outcome, even though this cut-off is not universally standardized (Table 2).

Table 2: Enemark scale

Scores 1 and 2 correspond to successful results.
Score 1: Bone level at 75-100% of normal height
Score 2: Bone level at 50-75% of normal height
Score 3: Bone level at 25-50% of normal height
Score 4: Bone level at 0-25% of normal height

2.4 Long scale

Long et al. [19] proposed this system as a refinement of the evaluation method described by Helms et al. [7]. The scale assesses the architecture of the operated cleft on periapical or occlusal x-rays by calculating multiple ratios between the height of the bony bridge and the root lengths of the adjacent teeth. As outlined in Table 3, several measurements are combined to provide a more detailed morphologic appraisal. Although the system does not use simple categorical labels, it does offer success criteria. Long et al. [19] considered the presence of a continuous bony bridge a sign of success, whereas bone notching extending to the apices or inadequate bone support adjacent to the cleft indicated failure. Aurouze et al. [20] later applied stricter criteria, suggesting that a case should be considered successful only when all measured ratios were normal.

Table 3: Long scale

Lengths measured	A: proximal segment root
	B: bone attachment along the distal surface of the proximal segment root
	C: distance from the alveolar crest bone on the distal surface of the proximal segment root to the cementoamel junction
	D: notching of the alveolar bone
	E: distal segment root
	F: bone attachment along the mesial surface of the distal segment root
	G: distance from the alveolar crest bone on the mesial surface of the distal segment root to the cementoamel junction
Ratios evaluated	B/A (normal value 1)
	C/A (normal value 0)
	D/A (normal value 0)
	F/E (normal value 1)
	G/E (normal value 0)

A major strength of the Long scale is that it describes both coronal and apical morphology in greater detail than simpler systems. By normalizing measurements to adjacent root length, it also attempts to reduce the effect of intraoral x-ray elongation. The authors further note that measurements may be taken at any tooth distal to the cleft and that canine eruption is not a prerequisite for evaluation [19, 20]. Its principal drawback is practical complexity: the number of measurements and calculations makes routine clinical application considerably more demanding than with simpler grading systems [13, 21] (Table 3).

2.5 Kindelan scale

Kindelan et al. [22] first described this scale, and it remains commonly used in the United Kingdom [23]. It estimates the percentage of bone fill by comparing preoperative and postoperative occlusal radiographs. Because it evaluates the defect itself rather than relying on the adjacent teeth, eruption of neighbouring teeth is not required. Table 4 presents the categories. Several studies [8, 9, 23] have treated 50% bone fill (grades 1 and 2) as the practical threshold for success. Revington et al. [24] additionally suggested that a satisfactory result should include a bony layer at the apices of the teeth on either side of the cleft. Important limitations are the need for a preoperative x-ray and the fact that the scale does not specify the precise location of the bony bridge within the defect [13] (Table 4).

Table 4: Kindelan scale

Grade 1: Bone fill in > 75% of the alveolar cleft area
Grade 2: Bone fill in 50 – 75% of the alveolar cleft area
Grade 3: Bone fill in < 50% of the alveolar cleft area
Grade 4: No complete bony bridge
Grades 1 and 2 correspond to successful results.

2.6 Chelsea scale

Witherow et al. [13] of the Chelsea and Westminster Cleft and Craniofacial Unit proposed this scale. It provides a relatively detailed description of the architecture of the bony bridge in the operated alveolar cleft on periapical or occlusal x-rays. The roots of the adjacent teeth are first divided into four quarters, and the cleft is separated vertically by an imaginary midline. Bone is then scored within each quarter as 0 (no bone), 0.5 (bone present but not reaching the midline), or 1 (bone present and reaching the midline). Each case is then assigned to one of the six categories summarized in Table 5.

Table 5: Chelsea scale

Group A: Presence of bone tissue at the amelocemental junction and at least 75% of both roots covered with bone
Group B: Presence of bone tissue in the amelocemental junction and in at least 25% of both roots
Group C: Presence of bone tissue across at least 75% of the cleft roots from an apical direction
Group D: Presence of bone tissue across at least 50% of both roots from an apical to coronal direction
Group E: Presence of a bony bridge in any area of the cleft except apically and coronally
Group F: Presence of bone tissue 25% or less across both roots from an apical direction
Groups A, B and C correspond to satisfactory results.

According to Witherow et al. [13], the procedure is considered successful when bone is present at the cervical quarter of the adjacent teeth (groups A and B) or across at least 75% of the cleft roots from an apical direction (group C). However, several authors have questioned whether group B, in which the bony bridge is limited to the cervical region, should automatically be regarded as a satisfactory outcome [25, 26, 27]. The Chelsea scale offers one of the most explicit descriptions of coronal and apical bridge morphology, and the authors state that measurements can be made at any tooth distal to the cleft during mixed dentition without requiring canine eruption. Its main limitation is the complexity of application, which may restrict routine clinical use [21] (Table 5).

2.7 SWAG scale

The Standardized Way to Assess Grafts (SWAG) scale was developed within the Americleft project in North America [28, 21, 10]. The aim of the Americleft project is to define core protocol components associated with favourable outcomes and to clarify the benefits of coordinated team care for patients with clefts. The SWAG system is based on periapical or occlusal x-rays. Bone is assessed independently in the apical, middle, and coronal thirds of the cleft, with each third assigned a score of 0 (absence of a bony bridge with exposed tooth roots), 1 (absence of a bony bridge with bone covering the tooth roots), or 2 (presence of a bony bridge). As shown in Table 6, the total score ranges from 0 (failed graft with poor re-graft prognosis) to 6 (complete cleft fill with normal alveolar bone height) by summing the three regional scores. According to Ruppel et al. [21], scores of 5 or 6 indicate complete success because a bony bridge is present in at least two thirds of the cleft site and no permanent tooth roots are exposed. By explicitly evaluating the entire cleft site, the SWAG scale incorporates both apical and coronal assessment. Because its thirds are referenced to the cleft rather than to adjacent teeth, it can be applied during mixed dentition. It also provides a relative estimate of re-grafting prognosis through its assessment of root coverage; cases with total scores of 3 or 4 are thought to have a better prognosis for re-grafting than cases with scores of 1 or 2 [21]. Although it does not require complex numeric measurements, its multi-step scoring process may still be less intuitive than simpler scales (Table 6) (Figure 1).

Table 6: SWAG scale

Score 0: No bone bridge; permanent tooth roots exposed in cleft site
Score 1: No bone bridge; no permanent tooth roots exposed in cleft site
Score 2: Bone bridge present in a cleft third; permanent tooth roots exposed in both other thirds (cleft site filled less than 1/2)
Score 3: Bone bridge present in a cleft third; permanent tooth roots exposed in one of the remaining thirds (cleft site filled less than 1/2)
Score 4: Bone bridge present in a cleft third; no permanent tooth roots exposed in both other thirds (cleft site filled less than 1/2) or Bone bridge present in two of the cleft thirds; permanent tooth roots exposed in the remaining third (cleft site filled more than 1/2)
Score 5: Bone bridge present in two of the cleft thirds; no permanent tooth roots exposed in the remaining third (cleft site filled more than 1/2)
Score 6: Complete bone fill-in; definitely more than 2/3 cleft site filled including up to and beyond actual or projected root apices
Scores 5 and 6 correspond to totally successful results

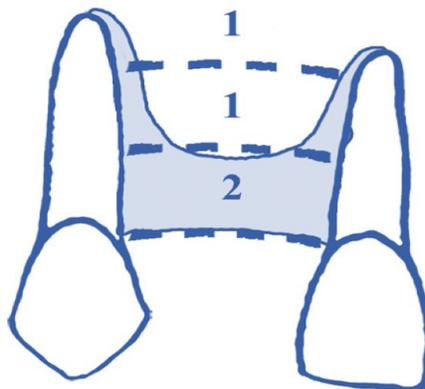


Figure 1: Schematic representation of the SWAG scale classification

3 Summary of scale properties

The following points synthesize the principal advantages and limitations of the reviewed plain-radiograph-based scales and highlight the features that make a scoring system clinically informative:

- **Simple:** Straightforward criteria support routine adoption and facilitate communication across teams, but simplicity should not come at the expense of overlooking clinically relevant apical or mid-root defects. The enduring use of the Bergland scale illustrates the practical value of a method that is easy to apply.
- **Reproducible:** For the Bergland, Kindelan, Chelsea, and SWAG scales, agreement between the same or different assessors is generally reported as good to excellent [16, 20, 18]. Even so, reproducibility depends on clear definitions, observer training, and consistent radiographic quality.
- **Assessment of the bone across the cleft site's height:** Newer scales evaluate bone levels both coronally and apically, whereas earlier systems focus mainly on the coronal aspect. This broader anatomic coverage is clinically important because deficits in the middle or apical third adjacent to neighbouring roots may influence orthodontic mobility, periodontal support, and implant planning [5, 21].
- **Clear outcome criteria:** Except for the Long scale, most systems explicitly recognize that the mere presence of a bony bridge is not sufficient to define success. Clinically meaningful interpretation requires thresholds that distinguish limited fill from functionally adequate support. In general, a marginal bone level below 50% of normal height or bone fill below 50% of the cleft deficit is unlikely to represent an effective result. Most scales, except Enemark and Chelsea, also retain a separate category for complete absence of a bony bridge.
- **Relevance in both mixed and permanent dentition:** A major practical challenge is that canine eruption usually occurs years after grafting, whereas many measurements are referenced to teeth adjacent to the cleft. Because the Kindelan scale evaluates the defect fill itself, it is least dependent on the status of neighbouring teeth. The Long and Chelsea scales can also be applied irrespective of the specific adjacent tooth. Witherow et al. [13] further suggest that the radiographic outcome is unlikely to change substantially after canine eruption. The SWAG scale assesses the bony bridge within thirds of the cleft site, which improves mixed-dentition applicability, although its simultaneous use of root exposure as a descriptor can complicate interpretation. Some studies continue to use the Bergland scale in mixed dentition despite the fact that it was originally intended for assessment after completion of orthodontic tooth movement [26, 29].

4 Conclusions

1. Conventional plain radiographs remain a practical and historically important basis for reporting outcomes after alveolar cleft repair, and the Bergland scale continues to serve as the most widely recognized reference standard.
2. The most clinically useful two-dimensional scale is one that balances simplicity with reproducibility, evaluates the full height of the cleft site, applies in both mixed and permanent dentition, and uses explicit success thresholds that reflect functional adequacy rather than mere bridge presence.

References

- [1] Boyne, Philip J. "Secondary bone grafting of residual alveolar and palatal clefts." *J Oral Surg* 30 (1972): 87-92.
- [2] Tai, Chi-Chia E., I. Scott Sutherland, and Leland McFadden. "Prospective analysis of secondary alveolar bone grafting using computed tomography." *Journal of Oral and Maxillofacial Surgery* 58.11 (2000): 1241-1249.
- [3] Dempf, Rupert, et al. "Alveolar bone grafting in patients with complete clefts: a comparative study between secondary and tertiary bone grafting." *The Cleft Palate-Craniofacial Journal* 39.1 (2002): 18-25.
- [4] Feichtinger, Matthias, Rudolf Mossböck, and Hans Kärcher. "Assessment of bone resorption after secondary alveolar bone grafting using three-dimensional computed tomography: a three-year study." *The Cleft Palate-Craniofacial Journal* 44.2 (2007): 142-148.
- [5] Åbyholm, Frank E., Olav Bergland, and Gunvor Semb. "Secondary bone grafting of alveolar clefts: a surgical/orthodontic treatment enabling a non-prosthetic rehabilitation in cleft lip and palate patients." *Scandinavian Journal of Plastic and Reconstructive Surgery* 15.2 (1981): 127-140.
- [6] Enemark, Hans, Steen Sindet-Pedersen, and Mette Bundgaard. "Long-term results after secondary bone grafting of alveolar clefts." *Journal of Oral and Maxillofacial Surgery* 45.11 (1987): 913-918.
- [7] Helms, Jill A., T. Michael Speidel, and Kevin L. Denis. "Effect of timing on long-term clinical success of alveolar cleft bone grafts." *American Journal of Orthodontics and Dentofacial Orthopedics* 92.3 (1987): 232-240.
- [8] Han, Kihwan, et al. "Long-term results of secondary alveolar bone grafting using a technique to harvest pure calvarial cancellous bone: Evaluation based on plain radiography and computed tomography." *Journal of Plastic, Reconstructive & Aesthetic Surgery* 70.3 (2017): 352-359.
- [9] Kumar, R., et al. "Secondary bone grafting of alveolar clefts: a review of outcome at two centres in Australia and the UK." *British Journal of Oral and Maxillofacial Surgery* 55.5 (2017): 496-499.
- [10] Russell, Kathleen, et al. "Reliability of the SWAG - the standardized way to assess grafts method for alveolar bone grafting in patients with cleft lip and palate." *The Cleft Palate-Craniofacial Journal* 54.6 (2017): 680-686.
- [11] Bergland, Olav, Gunvor Semb, and Frank E. Abyholm. "Elimination of the residual alveolar cleft by secondary bone grafting and subsequent orthodontic treatment." *The Cleft Palate Journal* 23.3 (1986): 175-205.
- [12] Bergland, Olav, et al. "Secondary bone grafting and orthodontic treatment in patients with bilateral complete clefts of the lip and palate." *Annals of Plastic Surgery* 17.6 (1986): 460-474.
- [13] Witherow, H., et al. "A new scale to assess radiographic success of secondary alveolar bone grafts." *The Cleft Palate-Craniofacial Journal* 39.3 (2002): 255-260.
- [14] Hynes, P. J., and M. J. Earley. "Assessment of secondary alveolar bone grafting using a modification of the Bergland grading system." *British Journal of Plastic Surgery* 56.7 (2003): 630-636.

- [15] Semb, Gunvor, Elisabeth Rønning, and Frank Åbyholm. "Twenty-year follow-up of 50 consecutive patients born with unilateral complete cleft lip and palate treated by the Oslo cleft team, Norway." *Seminars in Orthodontics*. Vol. 17. No. 3. WB Saunders, 2011.
- [16] Opitz, Charlotte, et al. "Radiographic evaluation of the transplant bone height in patients with clefts of the lip/alveolus/palate after secondary bone grafting." *Journal of Orofacial Orthopedics/Fortschritte der Kieferorthopädie* 60.6 (1999): 383-391.
- [17] Schultze-Mosgau, Stefan, et al. "Analysis of bone resorption after secondary alveolar cleft bone grafts before and after canine eruption in connection with orthodontic gap closure or prosthodontic treatment." *Journal of Oral and Maxillofacial Surgery* 61.11 (2003): 1245-1248.
- [18] Bayerlein, Thomas, et al. "Evaluation of bone availability in the cleft area following secondary osteoplasty." *Journal of Cranio-Maxillofacial Surgery* 34 (2006): 57-61.
- [19] Long Jr, Ross E., Barbara E. Spangler, and Mimi Yow. "Cleft width and secondary alveolar bone graft success." *The Cleft Palate-Craniofacial Journal* 32.5 (1995): 420-427.
- [20] Aurouze, Catherine, et al. "The presurgical status of the alveolar cleft and success of secondary bone grafting." *The Cleft Palate-Craniofacial Journal* 37.2 (2000): 179-184.
- [21] Ruppel, J. K., et al. "The Americleft Project: a comparison of short- and longer-term secondary alveolar bone graft outcomes in two centers using the standardized way to assess grafts scale." *The Cleft Palate-Craniofacial Journal* 53.5 (2016): 508-515.
- [22] Kindelan, Jeremy D., Robert R. Nashed, and Michael R. Bromige. "Radiographic assessment of secondary autogenous alveolar bone grafting in cleft lip and palate patients." *The Cleft Palate-Craniofacial Journal* 34.3 (1997): 195-198.
- [23] Paterson, Michael, et al. "Secondary alveolar bone grafting (CLEFTSiS) 2007-2010." *The Cleft Palate-Craniofacial Journal* 53.2 (2016): 141-146.
- [24] Revington, Peter J., et al. "Alveolar bone grafting: results of a national outcome study." *The Annals of The Royal College of Surgeons of England* 92.8 (2010): 643-646.
- [25] Trindade, Ivy Kiemle, et al. "Long-term radiographic assessment of secondary alveolar bone grafting outcomes in patients with alveolar clefts." *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 100.3 (2005): 271-277.
- [26] Peamkaroonrath, Chonthicha, Keith Godfrey, and Supaporn Chatrchaiwiwatana. "New clinical method for alveolar bone graft evaluation in cleft patients: a pilot study." *The Cleft Palate-Craniofacial Journal* 48.3 (2011): 286-292.
- [27] Maeda, Aya, et al. "Changes in grafted autogenous bone during edgewise treatment in patients with unilateral cleft lip/palate or alveolus." *The Cleft Palate-Craniofacial Journal* 51.5 (2014): 525-532.
- [28] Russell, Kathleen, et al. "A multicenter study using the SWAG scale to compare secondary alveolar bone graft outcomes for patients with cleft lip and palate." *The Cleft Palate-Craniofacial Journal* 53.2 (2016): 180-186.
- [29] Nightingale, Claire, et al. "Comparative reproducibility of three methods of radiographic assessment of alveolar bone grafting." *The European Journal of Orthodontics* 25.1 (2003): 35-41.