Localized Ridge Augmentation/Preservation. A Systematic Review

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Background: Osseointegrated implants have been documented as efficacious, however, their placement may be contraindicated in some patients due to insufficient bone volume. Techniques such as guided bone regeneration (GBR), immediate implantation, and distraction osteogenesis (DO) have been utilized as ridge enhancement therapies.

Rationale: This systematic review evaluates dental implant survival rates in patients treated with ridge augmentation or preservation techniques.

Focused Question: In patients requiring dental implant placement, what is the effect of localized ridge preservation versus implant placement without augmentation on implant survival and adverse effects?

Search Protocol: MEDLINE and Cochrane Oral Health Group Specialized Trial Register were searched. Hand searches were performed on *Clinical Oral Implants Research, International Journal of Oral and Maxillofacial Implants, International Journal of Periodontics and Restorative Dentistry, Journal of Clinical Periodontology, Journal of Periodontology*, and *Journal of Periodontal Research*. All searches were performed for articles published through April 2002.

Selection Criteria: Publications reporting survival rate of dental implants following ridge therapy were included in the analysis. Reports describing techniques were excluded.

Data Collection and Analysis: Due to the absence of controlled studies, a meta-analysis was not performed. Descriptive statistics are used to report the data.

Main Results

1. A total of 18 studies were included: 13 reporting on guided bone regeneration (GBR, 1,741 patients) and 5 on distraction osteogenesis (DO, 92 patients).
2. There is a high level of predictable implant survival in sites treated by GBR or DO.
3. These survival rates are similar to those of implants placed in native bone.

Reviewers' Interpretations: Survival rates were similar for both GBR and DO implants. These survival rates were similar to implants placed in native bone.

Ann Periodontol 2003;8:321-327.

KEY WORDS

Alveolar ridge augmentation; guided bone regeneration; dental implants; osteogenesis, distraction; review literature; comparison studies.

Treatment of partial and total edentulism with dental implants has become an accepted treatment in dentistry. Root-form implants following the concept of osseointegration have eclipsed other designs due to their documented predictability.[1-2] This efficacy of dental implants has been achieved by following well-known prerequisites described in the literature that which facilitate implant osseointegration including presence of sufficient bone volume. In patients with trauma, extensive bone resorption, or anatomic limitations, dental implant placement may be contraindicated. Generally, sites with a deficient ridge have the treatment options of no implant placement, compromised implant position/length, or ridge-augmentation therapy.

The regeneration of the localized alveolar ridge immediately following extraction or for a chronic defect has been the goal of clinicians and researchers. The importance of the reconstruction in the past has been to enhance the pontic areas for placement of fixed partial dentures. Currently, this procedure allows the insertion of dental implants. Regenerative or preservation therapies should increase bone volume and idealize implant position. As bone

volume increases, longer and wider implants can be utilized. In addition, the idealized ridge can afford a proper emergence profile which optimizes esthetics and a restoration that is less difficult to fabricate.

The methodologies utilized to reconstruct the alveolar ridge have varied and include reconstruction with extraoral block autogenous grafts and treatment of localized alveolar defects, which require less invasive techniques.[3-6] Currently, guided bone regeneration utilizing a barrier membrane covering an autogenous graft has been considered the standard of care. In addition, many investigators have found that grafts placed with barrier membranes have lower amounts of resorption. Clinicians commonly use autografts, allografts, and xenografts, as well as synthetic compounds. Overall, the perception of the clinician has been that ridge augmentation is successful. However, the efficacy parameters and documentation used have varied or were incomplete. Since the purpose of an augmentation procedure is to have sufficient bone for the placement of a dental implant, a logical outcome would be the survival rate of fixtures placed in regenerated bone compared to dental implants placed in native bone. The purpose of this systematic review is to evaluate dental implant survival rates in patients who have been treated with ridge augmentation or preservation.

RATIONALE

This systematic review evaluates dental implant survival rates in patients treated with ridge augmentation or preservation techniques.

FOCUSED QUESTION

The review was intended to answer the following focused question: "In patients requiring dental implant placement, what is the effect of localized ridge preservation versus implant placement without augmentation on implant survival and adverse effects?"

SEARCH PROTOCOL

Data Sources and Search Strategy

The MEDLINE and Cochrane Oral Health Group databases were utilized to search for studies. The search strategy developed included the following terms: dental implants; endosseous implants; dental implantation; guided bone regeneration; bone regeneration; guided bone augmentation; ridge augmentation; human; English; socket or ridge preservation; immediate implantation; growth factors; distraction osteogenesis; ridge splitting or ridge expansion.

The searching of databases and hand searching of *Clinical Oral Implants Research, International Journal of Oral and Maxillofacial Implants, International Journal of Periodontics and Restorative Dentistry, Journal of Clinical Periodontology, Journal of Periodontology*, and *Journal of Periodontal Research* were completed up to April 2002.

Selection Criteria

The systematic review protocol defined the inclusion criteria for study eligibility. All study types were considered due to the absence of randomized controlled trials. The populations (subjects) were patients with inadequate bone to insert a dental implant who were treated by localized ridge augmentation/preservation utilizing various techniques and materials. Reports describing techniques were excluded.

Outcomes

The type of outcomes assessed were: primary outcome: implant survival rate; secondary outcomes: implant survival rate and change in bone height/width; patient-centered outcome: functional dental implant status; adverse outcomes: membrane exposure, reduced results, and effects of smoking. The review also attempted to determine the time of follow-up after implant placement.

Data Collection and Analysis

Following the database and hand searches, 2 reviewers (JPF, MLN) screened the titles and abstracts. An appraisal form for data abstraction was utilized and included: Intervention (e.g., guided bone regeneration); number of patients; implant success rate (percent); implant survival rate (percent); Length of follow-up (months); study type (e.g., prospective, retrospective); change in height/width (millimeters); implant under functional load (percent); rate of membrane exposure (percent); effect of smoking on implant survival; and reduced results.

Agreement between the 2 reviewers was determined for the inclusion or exclusion of reports. Due to the absence of controlled studies, a meta-analysis was not performed. Descriptive statistics were utilized to report the data. In order to standardize and clarify ambiguous data, dental implant survival was reported for each publication.

Ranking of Studies

MAIN RESULTS

The search strategy of MEDLINE and Cochrane databases found 530 and 36 publications respectively. Hand-searching revealed an additional one publication. A total of 37 studies were identified by the reviewers for data abstraction. The data collection indicated that 18 of the 37 articles could be analyzed. These 18 studies were stratified into 2 different interventions: guided bone regeneration (13)[7-19] and distraction

osteogenesis (5)[20-24] (Tables 1 and 2).[7-23] The only consistent outcome variables for the analysis were implant survival rate and length of follow-up time. The study populations in the 18 publications range from 7 to 440. Distraction osteogenesis, a more recently described technique, had a mean sample population of 17.4 patients compared to the more established GBR therapies, which had a mean of 133.9. This trend was also observed when comparing the length of the follow-up periods. The mean ±SD observation time (months) for DO (18.6 ± 19.4) was less than GBR (56.5 ± 25.5). When the primary outcome variable was evaluated, the mean ± SD percent implant survival rate for GBR (95.8 ± 5.3) was similar to DO (97.2 ± 4.2).

DISCUSSION

The systematic review process revealed several potential interventions including traditional guided bone regeneration and more recent therapies such as immediate implantation and distraction osteogenesis. The search strategy focused question attempted to evaluate an outcome of implant survival, which had clinical reality. Specifically, was there evidence that an intervention could not only produce sufficient bone to support a dental implant but also that the implant would be successful? Traditional studies in implant dentistry have been centered on success/survival rate in native bone. Many of these investigations have been undertaken to generate product-specific data. As a result, these studies have defined characteristics of a large case-series study without a control group. In contrast, the developments in the areas of guided bone regeneration, immediate implantation, and distraction osteogenesis have been motivated by the clinician who desires a more predictable outcome for the patient. The studies in this area are numerous as indicated by the data from the search strategy. Unfortunately, the vast majority of these studies describe techniques and not the outcome of implant survival. In addition, inadequate study designs, primarily in the areas of data analysis and interpretation, limit the utility of many investigations. As a result, in this systematic review, the data analysis was limited to survival rate and observation period.

Guided Bone Regeneration

Over the past decade, guided bone regeneration has been refined to a level where dental implant placement and an optimal position is possible. Preclinical and clinical research has documented the efficacy of various techniques and materials,[24-25] although most clinicians concur that a barrier membrane covering autogenous bone is the standard of care. However, in many cases the limitation with autogenous bone harvest directs the practitioner to utilize allografts or xenografts. The systematic search in the area of GBR resulted in 13 publications with sufficient information to provide data for analysis (Table 1). Overall, implants inserted in a site where bone was regenerated were predictable. In general, these studies were conducted in private offices enhancing the applicability of the results to the practitioner. Several publications noted in the review had survival rates above 96%.[11,13,16] Of these reports, Brocard et al.,[16] Nevins et al.,[13] and Fugazzatto et al.[11] provide extensive data with survival rates of 92.5%, 97.5%, and 97.6%, respectively. In these publications, study samples ranged from 331 to 440 patients. Investigations by Dahlin et al.,[7] Jovanoic

Table 1.

Studies on Guided Bone Regeneration

Reference	N Patients	Survival Rate (%)	Observation* Period	Study Design	Ranking
Dahlin et al.[7] 1991	6	100	36	CS	II-3
Jovanovic et al.[8] 1992	11	100	12	CS	II-3
Buser et al.[9] 1996	9	100	60	CS	II-3
Cosci & Cosci[10] 1997	353	99.5	84	CS	II-3
Fugazzotto et al.[11] 1997	331	97.6	51	CS	II-3
Mayfield et al.[12] 1998	7	100	24	CT	II-2
Nevins & Mellonig[13] 1998	352	97.5	74	CS	II-3
Becker et al.[14] 1999	51	85.7	60	CS	II-3
Lorenzoni et al.[15] 1999	63	100	24	CS	II-3
Brocard et al.[16] 2000	440	92.5	84	CS	II-3
Corrente et al.[17] 2000	29	91.7	76	CT	II-2
Brunel et al.[18] 2001	14	86	84	CS	II-3
Zitzmann et al.[19] 2001	75	95.8	60	CT	II-2
Mean ± SD		95.8 ± 5.3	56.5 ± 25.5		

* Maximum in months.

et al.,[8] and Buser et al.[8] demonstrate survival rates of 100%. However these reports could be considered case series due to the limited sample size and follow-up period. With 3 exceptions, Mayfield et al.,[12] Zitzmann et al.,[19] and Corrente et al.,[17] none of the studies included a control group. Mayfield et al. found no difference in implant survival with or without GBR.[12] Zitzmann et al. reported a 1.5% greater survival rate in the control group compared to GBR.[19] Corrente et al. evaluated implant survival in a controlled study comparing implants placed in regenerated versus native bone in 29 patients over maximum observation periods of 76 months (regenerated bone group) and 82 months (native bone group). These investigators demonstrated a survival rate in the GBR group of 92.3% as compared to 98.3% in native bone.[17] Two publications, Becker et al.[14] and Brunel et al.,[18] had a lower survival rate of 85.7% and 86%. These reduced the survival rate for GBR. Overall, the data analysis from this review indicates that dental implants in regenerated bone are successful. Further analysis of the publications regarding membrane, graft, or study types could not be completed due to insufficient data.

The dental surgeon has increasingly utilized immediate implant insertion due to the reduced time to complete a case. In a retrospective study, Cosci and Cosci found that the immediate placement in 353 patients result in a dental implant survival rate of 99.5%.[10] The follow-up period was up to 84 months. The survival rate for immediately placed implants may be attributed to placement of the implant in native bone. The influence of extraction socket size and shape may also be a cofactor for survival of the implant.

Distraction Osteogenesis

The challenges of vertical augmentation have led to the application of distraction osteogenesis (DO) as a part of ridge augmentation therapy. In this therapy, a segmental osteotomy is created and the bone is moved by activation of a distractor. The systematic review revealed a limited number of studies (Table 2) that reported dental implant survival rates following distraction.[20-24] In these reports, study populations ranged from 8 to 35 subjects, with a shorter evaluation time when compared to GBR. As a clinical outcome, linear gain was striking in these 5 investigations with a mean of 7.45 mm. McAllister reported an average vertical augmentation of 7 mm and a 100% implant survival rate of 16 implants over an observation period ranging between 13 to 30 months.[23] Jensen et al. reported in a long-term follow-up period up to 4.4 years of functional load, survival rate for implants following DO was 90.5%.[24] As the review indicates, this is a developing technique with significant potential. Some limitations include unidirectional movement, advanced surgical training, patient compliance and significant complications associated with failure (loss of the osseous segment).

Augmentation Techniques

The placement of dental implants in augmented/preserved sites can also include ridge splitting/expansion techniques and vertical bone ridge augmentation. Due to the limited data sets, an analysis of implant survival rates and follow-up period could not be completed. Two publications reported dental implant survival rate following ridge splitting/expansion.[25,26] Engelke et al. placed a total of 121 implants in 44 patients in conjunction with the ridge-splitting procedure. Subjects were followed for up to 34 months with a survival rate of 90.3%.[25] Scipioni et al. reported a dental implant survival rate of 98.5% in 170 patients who were treated with a ridge-splitting procedure.[26] Another challenging area of clinical interest has been the vertical augmentation of the deficient ridge. The systematic review identified 2 clinical groups with 4 publications.[27-30] The publications detail techniques involving various barrier and graft materials. Simion et al. reported a mean vertical augmentation of 3.14 mm with demineralized freeze-dried bone allograft and 5.02 with autograft.[27] In a subsequent publication, Simion et al. also reported a dental implant survival rate of 97.5% following a 1- to 5-year follow-up period of 123 implants.[28] Tinti et al. reported a mean vertical augmentation of 4.95 mm.[30]

Table 2.

Studies on Distraction Osteogenesis (all CS; with II-3 ranking)

Reference	N Patients	Distraction Height Achieved	Implant Survival Rate (%)	Observation Period	Functional Load
Gaggl et al.[20] 2000	35	4.97 mm	100	9	Yes
Chiapasco et al.[21] 2001	8	8.5 mm	100	12	Yes
Rachmiel et al.[22] 2001	14	10.3 mm	95.6	6	No
McAllister[23] 2001	7	7.0 mm	100	13	Yes
Jensen et al.[24] 2002	28	6.5 mm	90.5	53	Yes
Mean ± SD			96.5 ± 4.5	20.0 ± 22.1	

* Maximum in months.

Augmentation of the deficient ridge has been accomplished with the growth factor, recombinant human bone morphogenetic protein-2 (rhBMP-2). Howell et al.[31] and Cochran et al.[32] reported utilizing rhBMP-2 in a total of 12 patients. These studies of local ridge preservation and augmentation utilized a 0.43 mg/ml rhBMP-2/absorbable collagen sponge (ACS) device. The clinical results suggested that the device was well tolerated locally and systemically, with no adverse events. The rhBMP-2/ACS was easy to handle and could be adapted to the ridge or extraction site. Cochran et al. reported a dental implant survival rate of 100% over a 3-year follow-up period.[32] Ridge preservation with rhBMP-2 has also been evaluated. In a recent randomized controlled masked study, Fiorellini et al. reported on buccal wall defects following tooth extraction treated with rhBMP-2/ACS, ACS alone, or no graft (unpublished data). Results from the 1.5 mg/ml group had significantly more bone formation than the ungrafted or ACS-alone treated groups. Dental implant success in the rhBMP-2 group had similar success rates to native bone after 3 years in function, whereas implants were not able to be placed in the ungrafted negative control sites (unpublished data).

REVIEWERS' CONCLUSIONS

The survival of dental implants in the ridge therapies identified by the systematic review indicated a high level of predictably and similar to implants placed in native bone. However, the literature did not contain several data categories, which could be important in clinical decision-making. One area of interest would be the survival rate of augmentation in the GBR therapies. Although the implant survival rate demonstrated predictability, the GBR could be lower. This would have a negative impact on patient outcomes. The included studies also did not provide data on replacement fixtures, implant dimensions, and surface types. All of these factors could influence survival rates.

REFERENCES

1. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. *Clin Oral Impl Res* 1997;8:161-172.
2. Jemt T, Lekholm U, Adell R. Osseointegrated implants in the treatment of partially edentulous jaws: A preliminary study on 876 consecutively placed fixtures. *Int J Oral Maxillofac Implants* 1989;4:211-217.
3. Buser D, Brägger U, Lang NP, Nyman S. Regeneration and enlargement of jaw bone using guided tissue regeneration. *Clin Oral Impl Res* 1990;1:22-32.
4. Buser D, Dula K, Belser UC, Hirt H-P, Berthold H. Localized ridge augmentation using guided bone regeneration. I. Surgical procedure in the maxilla. *Int J Periodontics Restorative Dent* 1993;13:29-45.
5. Buser D, Dula K, Belser UC, Hirt HP, Berthold H. Localized ridge augmentation using guided bone regeneration. II. Surgical procedure in the mandible. *Int J Periodontics Restorative Dent* 1995;15:11-29.
6. Nevins M, Mellonig JT. Enhancement of the damaged edentulous ridge to receive dental implants: A combination of allograft and the Gore-Tex membrane. *Int J Periodontics Restorative Dent* 1992;12:97-111.
7. Dahlin C, Lekholm U, Linde A. Membrane-induced bone augmentation at titanium implants. A report on ten fixtures followed from 1 to 3 years after loading. *Int J Periodontics Restorative Dent* 1991;11:273-281.
8. Jovanovic SA, Spiekermann H, Richter EJ. Bone regeneration around titanium dental implants in dehisced defect sites: A clinical study. *Int J Oral Maxillofac Implants* 1992;7:233-245.
9. Buser D, Dula K, Lang NP, Nyman S. Long-term stability of osseointegrated implants in bone regenerated with the membrane technique: 5-year results of a prospective study with 12 implants. *Clin Oral Impl Res* 1996;7:175-183.
10. Cosci F, Cosci B. A 7-year retrospective study of 423 immediate implants. *Compendium Continuing Educ Dent* 1997;18:940-942.
11. Fugazzotto PA, Shanaman R, Manos T, Shectman R. Guided bone regeneration around titanium implants: Report of the treatment of 1,503 sites with clinical re-entries. *Int J Periodontics Restorative Dent* 1997;17:293-299.
12. Mayfield L, Skoglund A, Nobréus N, Attström R. Clinical and radiographic evaluation, following delivery of fixed reconstructions, at GBR treated titanium fixtures. *Clin Oral Impl Res* 1998;9:292-302.
13. Nevins M, Mellonig JT, Clem DS, Reiser GM, Buser DA. Implants in regenerated bone: Long-term survival. *Int J Periodontics Restorative Dent* 1998;18:35-45.
14. Becker W, Dahlin C, Lekhohlm U, et al. Five-year evaluation of implants placed at extraction and with dehiscences and fenestration defects augmented with ePTFE membranes: Results for a prospective multicenter study. *Clin Implant Dent Related Res* 1999;1:27-32.
15. Lorenzoni M, Pertl C, Polansky RA, Wegscheider WA. Guided bone regeneration with barrier membranes–a clinical and radiographic follow-up study after 24 months. *Clin Oral Impl Res* 1999;10:16-23.
16. Brocard D, Barthet P, Baysee E, et al. A multicenter report on 1,022 consecutively placed ITI implants: A 7-year longitudinal study. *Int J Oral Maxillofac Implants* 2000;15:691-700.
17. Corrente G, Abundo R, Cardaropoli D, Cardaropoli G, Martuscelli G. Long-term evaluation of osseointegrated implants in regenerated and nonregenerated bone. *Int J Periodontics Restorative Dent* 2000;20:391-397.
18. Brunel G, Brocard D,Duffort JF, et al. Bioabsorbable materials for guided bone regeneration prior to implant placement and 7-year follow-up: Report of 14 cases. *J Periodontol* 2001;72:257-264.
19. Zitzmann NU, Schärer P, Marinello CP. Long-term results of implants treated with guided bone regeneration: A 5-year prospective study. *Int J Oral Maxillofac Implants* 2001;16:355-366.
20. Gaggl A, Schultes G, Kärcher H. Vertical alveolar ridge distraction with prosthetic treatable distractors: A clinical investigation. *Int J Oral Maxillofac Implants* 2000;15:701-710.
21. Chiapasco M, Romeo E, Vogel G. Vertical distraction osteogenesis of edentulous ridges for improvement of oral implant positioning: A clinical report of preliminary results. *Int J Oral Maxillofac Implants* 2001;16:43-51.
22. Rachmiel A, Srouji S, Peled M. Alveolar ridge augmentation by distraction osteogenesis. *Int J Oral Maxillofac Surg* 2001;30:510-517.

23. McAllister BS. Histologic and radiographic evidence of vertical ridge augmentation utilizing distraction osteogenesis: 10 consecutively placed distractors. *J Periodontol* 2001;72:1767-1779.
24. Jensen OT, Cockrell R, Kuhlke L, Reed C. Anterior maxillary alveolar distraction osteogenesis: A prospective 5-year clinical study. *Int J Oral Maxillofac Implants* 2002; 17:52-68.
25. Engelke WGH, Diederichs CG, Jacobs HG, Deckwer I. Alveolar reconstruction with splitting osteotomy and mircrofixation of implants. *Int J Oral Maxillofac Implants* 1997;12:310-318.
26. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: A five-year study. *Int J Periodontics Restorative Dent* 1994;14:451-459.
27. Simion M, Jocanovic SA, Trisi P, Scarano A, Piattelli A. Vertical ridge augmentation around dental implants using a membrane technique and autogenous bone or allografts in humans. *Int J Periodontics Restorative Dent* 1998;18:9-23.
28. Simion M, Jovanovic SA, Tinti C, Benfenati SP. Long-term evaluation of osseointegrated implants inserted at the time or after vertical ridge augmentation. A retrospective study on 123 implants with 1-5 year follow-up. *Clin Oral Impl Res* 2001;12:35-45.
29. Tinti C, Parma-Benfenati S. Vertical ridge augmentation: Surgical protocol and retrospective evaluation of 48 consecutively inserted implants. *In J Periodontics Restorative Dent* 1998;18:435-443.
30. Tinti C, Parma-Benfenati S, Polizzi G. Vertical ridge augmentation: What is the limit? *Int J Periodontics Restorative Dent* 1996;16:221-229.
31. Howell TH, Fiorellini J, Jones A, et al. A feasibility study evaluating rhBMP-2/absorbable collagen sponge device for local alveolar ridge preservation or augmentation. *Int J Periodontics Restorative Dent* 1997;17:125-140.
32. Cochran DL, Jones AA, Lilly LC, Fiorellini JP, Howell H. Evaluation of recombinant human bone morphogenetic protein-2 in oral applications including the use of endosseous implants: 3-year results of a pilot study in humans. *J Periodontol* 2000;71:1241-1257.

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Accepted for publication August 16, 2003.

APPENDIX A
CONSENSUS REPORT

Members of the Section read and studied the review on "Localized Ridge Augmentation/Preservation. A Systematic Review" by Joseph P. Fiorellini and Marc L. Nevins. The focused PICO question addressed by this evidence-based systematic review is: "In patients requiring dental implant placement, what is the effect of localized ridge augmentation/preservation versus implant placement without augmentation on implant success and adverse events?"

INTRODUCTION

The Consensus Report represents a collaborative effect of the Section members. The preparation of the report prompted considerable assessment of the localized ridge augmentation/preservation systematic review. The Section members recognize that the outcome of implant success following ridge augmentation therapy is important to the patient as well as the clinician. The discussions and decisions reflected agreement in this area. In addition, Section participants also discussed techniques that lead to the placement of dental implants. Although many studies document the efficacy and importance of these procedures, many do not report dental implant survival and success. In addition, in studies that report on dental implant survival and success in augmented bone, the success rate of the augmentation procedures used are not presented. Procedures including socket bone augmentation and immediate implant placement are predictable and should be a component of patient care.

1. Does the Section agree that the evidence-based systematic review is complete and accurate?

Yes. The Section members found that the reviewers were thorough and complete in assimilating a systematic review of evidence-based data for localized ridge augmentation. The following additions were determined relevant by the Section.

The definitions of success and survival vary between studies. The Section members recommend the following definitions be adopted and be considered for inclusion in the next edition of the *Glossary of Periodontal Terms*.[1]

Implant survival: The longevity of the dental implant in function regardless of status.

Implant success: The quality of implant function and esthetics according to the criteria of Albrekttson et al.[2] as modified and published in the AAP position paper on "Implants in Periodontal Therapy:"[3] 1) absence of persistent signs and symptoms of disease; 2) absence of implant mobility; 3) absence of continuous peri-implant radiolucency; 4) negligible progressive bone loss (less than 0.2 mm annually) after physiologic remodeling; and 5) patient and dentist satisfaction with the implant supported prosthesis.

The search strategy developed for the focused question should have included block bone grafting for localized augmentation prior to implant placement. Several reports have documented similar implant survival with this technique.[4-6]

2. Has any new information been generated or discovered since the evidence-based search cut-off date?

Yes, two additional publications that provide supportive information have been identified.

In a systematic review, Hämmerle et al. found that studies reporting dental implant survival in regener-

ated bone were similar to dental implants placed conventionally into sites without the need for bone augmentation.[7]

In a recent randomized controlled masked study, Fiorellini et al. (unpublished data) reported on buccal wall defects following tooth extraction treated with rhBMP-2/absorbable collagen sponge (ACS), ACS alone, or no graft. Results from the 1.5 mg/ml group had significantly more bone formation than the ungrafted or ACS alone treated groups. Dental implant success in the rhBMP-2 group had similar success rates to native bone after 3 years in function, whereas implants were not able to be placed in the ungrafted negative control sites (unpublished data).

3. Does the Section agree with the interpretations and conclusions of the reviewers?

The Section members found the interpretations and conclusions of the reviewers thorough and accurate.

4. What further research needs to be done relative to the focused questions of the evidence-based review?

While the Section realizes the value of additional well-designed cohort studies or RCTs for the evaluation of various ridge augmentation materials and techniques, the challenges and multifactorial nature of these studies encouraged the Section members to limit recommendations for further research to the following

While no absolute contraindications exist in the literature, it would be beneficial to evaluate implant success as it relates to potential risk factors such as: membrane exposure, primary flap closure, initial implant stability, graft containment, periodontal disease, occlusal loading, smoking, and other systemic and behavioral factors.

Studies are needed to determine if multiple grafting procedures or techniques are required in the treatment of some bone defects to optimize the esthetic and functional outcome of implant reconstruction.

Studies are warranted to evaluate tissue-engineering techniques (e.g., molecular, cellular, and genetic) that may reduce the time required prior to prosthesis delivery and may enhance bone quality and quantity.

5. How can the information from the evidence-based review be applied to patient management?

The field of implant dentistry is a critical component of patient care. Success of dental implants in native bone has strong evidence to support their use. The development of techniques and materials for localized ridge augmentation has evolved to a point that there is evidence to support several types of augmentation procedures.

A. Socket bone augmentation. There is evidence to support the use socket bone augmentation for localized ridge augmentation. Dental implants placed at sites augmented by this method are successful under functional loads.

Level of Evidence:[8] Moderate.

Rationale: Assignment of a "moderate" level of evidence is based on 1 level I RCT and 5 level II-3 case series studies.

B. Horizontal Bone Augmentation. There is evidence to support the use of horizontal bone augmentation techniques (e.g., simultaneous and staged bone augmentation) to achieve dental implant success rates similar to those when the implants are placed in native bone.

Level of Evidence: Moderate.

Rationale: Assignment of a "moderate" level of evidence is based on 3 level II-2 and 10 level II-3 studies.

C. Vertical Bone Augmentation. There is some evidence to support the use of vertical bone augmentation techniques (e.g., simultaneous and staged bone augmentation and distraction osteogenesis) in achieving successful dental implants.

Level of Evidence: Limited.

Rationale: Assignment of a "limited" level of evidence is based on 2 level II-2 and 7 level II-3 case reports.

REFERENCES

1. The American Academy of Periodontology. *Glossary of Periodontal Terms*, 4th edition. Chicago: The American Academy of Periodontology; 2001.
2. Albrektsson T, Zarb G, Worthington P, Eriksson RA. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. *Int J Oral Maxillofac Implants* 1986;1:11-25.
3. The American Academy of Periodontology. Dental implants in periodontal therapy (position paper). *J Periodontol* 2000;71:1934-1942.
4. Urbani G, Lombardo G, Santi E, Consolo U. Distraction osteogenesis to achieve vertical bone regeneration: A case report. *Int J Periodontics Restorative Dent* 1999;19: 321-331.
5. Sethi A, Kaus T. Ridge augmentation using mandibular block bone grafts: Preliminary results of an ongoing prospective study. *Int J Oral Maxillofac Implants* 2001;16: 378-388.
6. Pikos MA. Block autografts for localized ridge augmentation: Part II. The posterior mandible. *Implant Dent* 2000;9:67-75.
7. Hämmerle CHF, Jung RE, Feloutzis A. A systematic review of the survival of implants in bone sites augmented with barrier membranes (guided bone regeneration) in partially edentulous patients. *J Clin Periodontol* 2002;29 (Suppl. 3):226-231.
8. Newman MG, Caton J, Gunsolley JC. The use of the evidence-based approach in a periodontal therapy contemporary science workshop. *Ann Periodontol* 2003;8:1-11.

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