Systematic analysis on the efficacy of bone enhancement methods used for success in dental implants

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Abstract: Bone grafting is beneficial in enhancing bones that are lost due to trauma or natural or pathologic process. Autogenous bone, allogenic bone, xenogeneic bone, bone substitutes, and alloplasts can also be used for this purpose. Bone quantity should be adequate for the placement of implants, which necessitate the use of bone grafts before implant placement.

Objective: This review analyses the different bone graft materials that are used for grafting around implants and evaluate if these grafts yield successful implant osseointegration over a period of time.

Materials and Methods: The MEDLINE–PubMed database was searched from September 2016 to 10 years previously. Several journals were hand searched and from cross-references. The primary outcome measure that was analyzed was the survival rate of dental implants in the grafted sites at 6 months–1 year, and the secondary outcomes were success rates of dental implants over a period of 3–5 years’ follow-up.

Results: The search yielded 213 articles. Ultimately, 31 studies meeting the eligibility criteria were selected. The analysis shows that autologous bone grafts can be preferred over allografts and xenografts for grafting implant sites, which showed less complication and high success rate.

Conclusion: Based on the available data in the current existing studies with a follow-up period of at least 3–5 years, it can be summarized that the autologous bone grafts can be preferred over allografts and xenografts for grafting implant sites since they are stable for at least 3–5 years.

Keywords: Bone grafts, bone loss, dental implants, implant success

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INTRODUCTION

Most patients present after tooth loss with a wide range of bone loss, which may not accommodate a dental implant prosthesis. Bone grafting is beneficial in enhancing bones that are lost due to trauma or natural or pathologic process. Autogenous bone, allogenic bone, xenogeneic bone, bone substitutes, and alloplasts are commonly used for this purpose.\(^1\)

The long-term success of dental implants is highly dependent upon the degree of osseointegration in sufficient and healthy bone.\(^2\) Implants have a predictable outcome and are the advanced treatment option for edentulous patients.\(^3\)
Bone augmentation helps in providing sufficient quality and quantity of the bone in the atrophic ridges for the placement of dental implants.[4] Grafts and guided bone regeneration techniques are used to improve primary stability during implant placement in atrophic ridges.[5] Hence, a systematic analysis was performed to check the efficacy of bone enhancement methods used for success in dental implants.

MATERIALS AND METHODS

The following analysis was performed according to the guidelines and the principles of the PRISMA statement for a systematic review.

Focused question patient intervention comparison and outcome

The review is focused on: “What is the efficacy of various types of bone enhancing grafts that leads to dental implants success?”

Search strategy

The MEDLINE–PubMed database was searched from September 2016 to 10 years previously.

The following search terms were used as shown in Figure 1.

Study inclusion criteria

The studies were analyzed according to the following inclusion criteria:[6-8]

1. All studies treated with bone grafts and implants with a follow-up of at least 1 year
2. Patients with reduced quantity of edentulous ridges resulted due to ridge resorption, periodontal diseases, and trauma were included
3. The following grafts were considered:[9-11]
   a. Autologous bone graft
   b. Allograft
   c. Composite bone grafts
   d. Xenograft.
4. Articles related to dental implants were considered for inclusion
5. All dental implant systems were included
6. Only studies in the English language were included
7. Only human studies were included.

Study exclusion criteria

The studies with following criteria were not included in the review:[12-14]

1. Studies involving only implants, without any bone graft
2. Case reports regarding patients with any syndrome or major systemic disease
3. Studies not related to implants and bone grafts
4. Studies not related to dentistry
5. Studies with insufficient information
6. Animal studies.

Data extraction

All studies which met the inclusion and exclusion criteria for review were obtained and screened independently. Relevant studies without abstract were included for full-text screening. The following data were extracted from the studies included for review:[15-20] publication, study design, number of patients, type of graft, number of dental implants, timing of implants, follow-up time, implant survival, and implant success rate. Quality of various studies regarding bone graft, implant success, and survival were considered for quality assessment of bone graft and implant [Figures 1 and 2].

Failure of bone grafts

The most frequent complication of graft failure may be due to exposure of bone graft, not proper stabilization of the graft, and infection.[21-26] Of the complications, only graft exposure was moderately associated with bone graft failure.[27]

The factors that can increase the risk of a bone graft failure are:[28,29]

- Periodontal disease
- Smoking
- Osteoporosis
- Surgical errors
- Systemic conditions such as uncontrolled diabetes
- Immune system deficiencies.

The implants placed in the autologous bone grafts had a higher survival rate when compared to those placed in other graft materials. Alloplastic material had a lower resorption rate when compared to autologous material.[30] The addition of bone substitute to autogenous grafts has been found to accelerate bone formation,[27-31] but interestingly, in this review, majority of studies found a higher rate of
graft failure in patients who received composite bone grafts [Tables 1 and 2].

**DISCUSSION**

In the review of the past studies, evidence is available about the efficacy of different types of bone grafts. This review tried to systematically evaluate the current evidence and to compare the different grafts in bone enhancement as well as the success of implants placed along with the graft in long-term follow-up. In total, 31 articles could be included, from which the data were obtained. To assess the success of implant placed in different bone grafts, all the 31 articles were reviewed for the following characteristics: design of the study, number of patients per study, graft type, surgical procedure and donor site, number of dental implants, timing of implants, follow-up time, implant survival, and implant success rate.

**Block graft**

Out of 31 included articles, 14 studies were using block graft. Of which, 11 studies were case reports while three were prospective. A total of 86 patients with reduced alveolar ridges were treated with block grafts. In total, 223 dental implants were placed after 3–6 months of grafting. The follow-up ranged from 1 to 5 years. The survival rates for the dental implants in grafted bone ranged from 97.3% to 100% and the mean was 98.5%.

**Particulate graft**

Out of 31 articles included, three studies were using particulate graft. Of these, all three were case reports. A total of three patients with reduced alveolar ridges were treated with particulate graft. In total, nine dental implants were placed after 4 months of healing. The follow-up ranged from 1 to 3 years and the mean was 1.7 years.

**Blood derivatives**

Out of 31 articles included, three studies have used blood derivatives as grafting material. A total of 15 dental implants were placed for 3 patients, of which 6 implants were placed immediately along with the graft material and 9 dental implants were placed after 2–3 months of healing. After the start of loading, the follow-up ranged from 1 to 4 years. Survival rate for the dental implants was 94.7%. The implant success rate was 93.2%.

**Composite bone graft**

Out of 31 articles included, seven studies have used composite bone as grafting material. Three studies were case report while four were case series. A total of five patients were treated with three different donor materials and 21 dental implants were placed after 4–12 months of graft healing. After the start of loading, the follow-up ranged from 1.0 to 5 years. The survival rate for the dental implants in grafts was 99.3%. The implant success rate was 90.7%.

**Xenograft**

Out of 31 articles included, only one study used xenograft as grafting material. One patient with reduced alveolar ridge was treated with bovine bone, mixed with fibrin adhesive. In total, three dental implants were placed after 6–12 months after healing of the graft material. After the start of loading, the follow-up ranged from 1 to 3 years. The survival rate for the dental implants was 85.4%. The implant success rate was 73.2%.
### Table 1: Characteristics of 31 studies included

| Reference                           | Study design | Number of patients | Graft materials                                                                 | Number of implants | Timing of implant placement                                      | Follow-up implant survival (%) | Implant success (%) |
|-------------------------------------|-------------|--------------------|-------------------------------------------------------------------------------|-------------------|-----------------------------------------------------------------|-------------------------------|--------------------|
| José-Luis Cebrian-Carretero         | Case series | 4                  | Fibula, iliac crest, and scapula-free flaps                                  | 19                | 6-12 months after reconstruction                                | 100                           | 100                |
| Balaji SM                           | Case report  | 1                  | BMP-rhBMP-2                                                                  | 6                 | No data                                                         | 100                           | 100                |
| Emir Yüzbaşıoğlu                    | Case report  | 1                  | Iliac bone graft                                                             | 3                 | 4 years 6 months after reconstruction                           | No data                       | No data            |
| Kristian Rude                       | Case report  | 1                  | Free vascularized fibula flap                                                | 5                 | Oral rehabilitation was carried out 12 months postoperatively   | 100                           | 100                |
| Hisahiro Kamoi                      | Case report  | 1                  | Rib bone                                                                     | 5                 | Dented implants inserted simultaneously during surgery          | 100                           | 100                |
| Po-Sung Fu                          | Case report  | 1                  | Autogenous bone harvested from the chin                                       | 1                 | 4 months after socket augmentation                              | 100                           | 100                |
| Pedro Infante Cossio                | Case report  | 1                  | Composite bone graft of autogenous bone, xenograft, and autologous PRP       | 2                 | 24 months after augmentation                                   | 100                           | 100                |
| Hideshi Sekine                      | Case report  | 1                  | Iliac bone block and PCBM                                                    | 5                 | On the right side, two implants were placed 4 months after bone grafting. On the left side, three implants were placed simultaneously after bone grafting. | 100                           | 100                |
| Masako Sawaki, et al.               | Case report  | 1                  | A PCBM graft and RBOG                                                        | 2                 | 5 months after bone grafting                                    | 100                           | 100                |
| Juliano de Alenear Vasconcelos, et al. | Case report   | 1                  | Bone tissue collected during the osteotomies and drilling processes           | 2                 | Bone graft placed at the same time of implant placement         | 100                           | 100                |
| Dr. Eugenio Miguel Pereira          | Case series  | 1                  | Fresh-frozen bone allograft from the iliac crest                              | 8                 | 5 months after grafting                                         | 100                           | 100                |
| Francesco Greccchi                  | Case report  | 1                  | Femur homografts                                                             | 12                | 8 weeks after grafting                                          | 100                           | 100                |
| Gui-Youn Cho-Lee                    | Case report  | 1                  | Free vascularized fibular flap                                               | 3                 | Implants placed after 3 months                                 | 100                           | 100                |
| Pedro Infante-Cossio                | Case report  | 1                  | Iliac crest graft                                                             | 3                 | 6 months and 2 weeks after grafting                             | 100                           | 100                |
| Po-Sung Fu                          | Case report  | 1                  | Chin graft                                                                   | 1                 | Implant placed after 4 months of grafting                      | 100                           | 100                |
| Dr. Gregory Taylor                 | Case report  | 1                  | Ramus graft                                                                  | 1                 | Implant placed after 6 months of grafting                      | 100                           | 100                |
| Mario Santagata1                    | Case series  | 11                 | Particulate bone graft                                                       | 633               | 4-6 months                                                    | 93.4                          | 83                 |
| Jee-Won Moon                        | Case report  | 1                  | Bovine bone, mixed with fibrin adhesive                                       | 3                 | Placed immediately                                             |                               |                    |
| Mi-Ra Ahn                           | Case series  | 11                 | Irradiated cancellous bone and marrow                                        | 27                | Placed after 5 months                                          | 99                            | 97.5               |
| Devorah Schwartz-Arad               | Retrospective study | 214              | Autologous intraoral block OBG augmentations, combined with Bio-Oss - mixed with PRP, and covered by PPP - as scaffold (PCBM) | 633               | 4-6 months                                                    | 93.4                          | 83                 |
| Thomas J. Balshi                    | Case report  | 1                  | Iliac crest bone graft                                                       | 2                 | Implants placed subsequently                                  | 50                            | 0                  |
| Matteo Chiapasco                    | Case series  | 3                  | Iliac crest                                                                  | 22                | 5-6 months                                                    | 100                           | 100                |
| Eduardo Anitua                      | RCT          | 23                 | PDGF and TGF-β                                                               |                   | Placed immediately                                             | 100                           | 100                |

Contd...
Table 1: Contd...

| Reference                  | Study design | Number of patients | Graft materials                                      | Number of implants | Timing of implant placement | Follow-up implant survival (%) | Implant success (%) |
|----------------------------|--------------|--------------------|-----------------------------------------------------|--------------------|------------------------------|-------------------------------|-------------------|
| Michael Peleg              | RCT          | 63                 | Autogenous composite bone graft consisting of a combination of 50% membranous bone harvested from the symphysis and 50% DFDBA | 160                | Placed immediately           | 100                           | 100               |
| Ji-Min Kim                 | Case series  | 63                 | Fibrin-rich block with concentrated growth factors  | 74                 | After 5 months               | 100                           | 96.6              |
| Gerry M. Raghoobar         | Case series  | 14                 | Zygomatic rim                                       | 14                 | No data                      | 100                           | 100               |
| Stefan Lundgren            | Case series  | 11                 | Bone flap                                           | 12                 | Placed immediately           | 94.7                          | 100               |
| Mats Sjöström              | Case series  | 29                 | Free iliac crest grafts                             | 192                | 6-8 months after grafting    | 100                           | 90                |
| Federico Hernández-Alfaro  | Case series  | 14                 | Mandibular bone block graft and biomaterials        | 113                | 14-16 weeks after grafting   | 88.4                          | 77.99             |
| Dong-Seok Sohn             | Case series  | 53                 | Fibrin-rich blocks with CGF                         | 113                | Placed simultaneously        | 99                            | 98.2              |
| Jee-Won Moon               | Case series  | 14                 | Peripheral venous blood                             | 31                 | Placed simultaneously        | 95.1                          | 93.5              |

CGF: Concentrated growth factor, DFDBA: Demineralized freeze-dried bone allograft, PDGF: Platelet-derived growth factor, TGF-β: Transforming growth factor-β, rhBMP2: Recombinant human bone morphogenetic protein-2, PCBM: Particulate cancellous bone and marrow, RBOG: Ramus bone onlay grafting, OBS: Onlay bone graft, PPP: Platelet-poor plasma, RCT: Randomized controlled trials, PRP: Platelet-rich plasma, BMP: Bone morphogenetic protein

RESULTS

The results of the study are depicted in Chart 1.

The mean value of the survival and success rate of the implants on various types of grafts is charted on a graph. From the chart, we can observe that:

- Block grafts have 98.9% survival rate and 99.05% success rate
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- Particulate grafts have 100% survival rate and 66.6% success rate
- Blood derivatives have 97.8% survival rate and 96.6% success rate
- Composite bone grafts have 99.6% survival rate and 66.06% success rate
- Allografts have 90.9% survival rate and 82.8% success rate.

CONCLUSION

Based on the available data in the existing studies with a follow-up period of at least 3–5 years, it can be summarized that the autologous bone grafts can be preferred over allografts and xenografts for grafting implant sites since they are stable for at least 3–5 years.

Among the various autologous grafts reviewed, block grafts and blood derivatives had a higher percentage of success rate. Hence, by following proper diagnostic and clinic protocol for implant placement, block grafts and blood derivatives can be used for better clinical outcome and success of the implant over a long period of time.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Tucker S, Cevidanes LH, Styner M, Kim H, Reyes M, Proffit W, et al. Comparison of actual surgical outcomes and 3-dimensional surgical simulations. J Oral Maxillofac Surg 2010;68:2412-21.
2. Sheikh Z, Sima C, Glogauer M. Bone replacement materials and techniques used for achieving vertical alveolar bone augmentation. Materials 2015;8:2953-93.
3. Kalle M, Karthik MS, Hegde C, Shetty SN, Raghotham K. Enhancement of support for mandibular complete denture prosthesis: A preprosthetic ridge augmentation procedure by distraction osteogenesis. J Indian Prosthodont Soc 2009;9:88.
4. Hegde R, Prasad K, Shroff KK. Maxillary sinus augmentation using sinus membrane elevation without grafts – A systematic review. J Indian Prosthodont Soc 2009;9:88.
5. Patil RC, Kanchan S, Ramanathan K. Immediate implant placement in conjunction with a DFDBA graft and resorbable membrane: A 1-10 year retrospective clinical study. J Indian Prosthodont Soc 2005;5:203.
6. Santagata M, Tozzi U, Prisco RV, Tartaro G, D’Amato S. Autologous bone graft harvested during implant site preparation: Histological study. Plast Aesthetic Res 2014;14:94.
7. Balaji SM. Augmentation of residual alveolar bone height with tissue engineering for dental implant placement. Indian J Dent Res 2014;25:410-2.
8. Yuzbasioglu E, Alkan A, Ozer M, Bayram M. Multidisciplinary approach for the rehabilitation of central giant cell granuloma: A clinical report. Niger J Clin Pract 2014;17:528-33.
9. Modabber A, Legros C, Rana M, Gerressen M, Riediger D, Ghassemi A. Evaluation of computer-assisted jaw reconstruction with free vascularized fibular flap compared to conventional surgery: A clinical pilot study. Int J Med Robot 2012;8:215-20.
10. Liu XJ, Gui L, Mao C, Peng X, Yu GY. Applying computer techniques in maxillofacial reconstruction using a fibula flap: A messenger and an evaluation method. J Craniofac Surg 2009;20:372-7.
11. Foley BD, Thayer WP, Honeybrook A, McKenna S, Press S. Mandibular reconstruction using computer-aided design and computer-aided manufacturing: An analysis of surgical results. J Oral Maxillofac Surg 2013;71:e111-9.
12. Moon JW, Sohn DS, Heo JU, Shin HI, Jung JK. New bone formation in the maxillary sinus using peripheral venous blood alone. J Oral Maxillofac Surg 2011;69:2357-67.
13. Kim JM, Lee JH, Park IS. New bone formation using fibrin rich block with concentrated growth factors in maxillary sinus augmentation. J Korean Assoc Oral Maxillofac Surg 2011;37:278-86.
14. Raghoorbard GM, Meijer HJ, Tellerman G, Vissink A. Maxillary sinus floor augmentation surgery with autogenous bone grafts as ceiling: A pilot study and test of principle. Clin Implant Dent Relat Res 2013;15:550-7.
15. Hidalgo DA. Fibula free flap: A new method of mandible reconstruction. Plast Reconstr Surg 1989;84:71-9.
16. Hidalgo DA, Relow A. A review of 60 consecutive fibula free flap mandible reconstructions. Plast Reconstr Surg 1995;96:585-96.
17. Wei FC, Chen HC, Chuang CC, Noordhoff MS. Fibular osteospectocutaneous flap: Anatomic study and clinical application. Plast Reconstr Surg 1986;78:191-200.
18. Foster RD, Anthony JP, Sharma A, Pogrel MA. Vascularized bone flaps versus nonvascularized bone grafts for mandibular reconstruction: An outcome analysis of primary bony union and endosseous implant success. Head Neck 1999;21:66-71.
19. Schusterman MA, Miller MJ, Reece GP, Kroll SS, Marchi M, Goepfert H. A single center’s experience with 308 free flaps for repair of head and neck cancer defects. Plast Reconstr Surg 1994;93:472-8.
20. Gbada A, Darwich K, Li L, Schmelze R, Blake F. Long-term results of jaw reconstruction with microsurgical fibula grafts and dental implants. J Oral Maxillofac Surg 2007;65:1005-9.
21. Olszewski R. Surgical engineering in cranio-maxillofacial surgery: A literature review. J Healthc Eng 2012;3:53-86.
22. Alobelbi DE, Kevin R, Mulliken JB, Cline H, Lorenzen W, Jolesz F. Computer-assisted three-dimensional planning in craniofacial surgery. Plast Reconstr Surg 1993;92:576-85.
23. Antony AK, Chen WF, Kolokythas A, Weimer KA, Cohen MN. Use of virtual surgery and stereolithography-guided osteotomy for mandibular reconstruction with the free fibula. Plast Reconstr Surg 2011;128:1080-4.
24. Gilbert A. Vascularized transfer of the fibular shaft. Int J Microsurg 1979;1:100-2.
25. Ling XF, Peng X. What is the price to pay for a free fibula flap? A systematic review of donor-site morbidity following free fibula flap surgery. Plast Reconstr Surg 2012;129:657-74.
26. Metzger MC, Hohlweg-Majert B, Schön R, Teschner M, Malluche H, Gellrich NC, Schmelzeisen R, et al. Verification of clinical precision after computer-aided reconstruction in craniomaxillofacial surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104:e1-10.
27. Foum SJ, Tarnow DP, Wallace SS, Rohrer MD, Cho SC. Sinus floor elevation using anorganic bovine bone matrix (OsteoGraf/N) with and without autogenous bone: A clinical, histologic, radiographic, and histomorphometric analysis – Part 2 of an ongoing prospective study. Int J Periodontics Restorative Dent 1998;18:528-43.
28. Rude K, Thygesen TH, Sorensen JA. Reconstruction of the maxilla using a fibula graft and virtual planning techniques. BMJ Case Rep 2014;2014 pii: Bcr2014203601.
29. Vaseconeels Jde A, Avila GB, Ribeiro JC, Dias SC, Pereira Jr. Inferior alveolar nerve transposition with involvement of the mental foramen for implant placement. Med Oral Patol Oral Cir Bucal 2008;13:e722-5.
30. Kaing L, Gruber D, Chanda A. Assessment of bone grafts placed
within an oral and maxillofacial training programme for implant rehabilitation. Aust Dent J 2011;56:406-11.

31. Thorwarth M, Schlegel KA, Wehrhan F, Srour S, Schultz-Mosgau S. Acceleration of de novo bone formation following application of autogenous bone to particulated anorganic bovine material in vivo. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:309-16.

32. Infante Cossío P, Martínez de Fuentes R, Carranza Carranza A, Torres Lagares D, Gutiérrez Pérez JL. Recurrent central giant cell granuloma in the mandible: Surgical treatment and dental implant restoration. Med Oral Patol Oral Cir Bucal 2007;12:E229-32.

33. Sekine H, Taguchi T, Seta S, Takano M, Takeda T, Kakizawa T. Dental implant treatment with different techniques for sinus floor elevation – A case report. Bull Tokyo Dent Coll 2007;48:87-91.

34. Sawaki M, Ueno T, Kagawa T, Kanou M, Honda K, Shirasu N, et al. Dental implant treatment for a patient with bilateral cleft lip and palate. Acta Med Okayama 2008;62:59-62.

35. Contar CM, Sarot JR, Bordini J, Galvão GH, Nicolau GV, Machado MA. Maxillary ridge augmentation with fresh-frozen allografts. Int J Maxillofac Surg 2009;67:1280-5.

36. Grecchi F, Mancini G, Parafioriti A, Mineo G, Zollino I, Piccolo A, et al. Ectodermal dysplasia treated with one-step surgical rehabilitation: A case report. Singapore Dent J 2010;31:9-14.

37. Cho-Lee GY, Naval-Gías L, Martos-Díaz PL, González-García R, Rodríguez-Campo FJ. Vertical distraction osteogenesis of a free vascularized fibula flap in a reconstructed hemimandible for mandibular reconstruction and optimization of the implant prosthetic rehabilitation. Report of a case. Med Oral Patol Oral cir Bucal 2011;16:e74-8.

38. Infante-Cossío P, Martínez-de-Fuentes R, García-Perla-García A, Jiménez-Castellanos E, Gómez-Izquierdo L. Myxofibroma of the maxilla. Reconstruction with iliac crest graft and dental implants after tumor resection. Med Oral Patol Oral Cir Bucal 2011;16:e532-6.

39. Fu PS, Wu YM, Tsai CF, Huang TK, Chen WC, Hung CC. Immediate provisional restoration of a single-tooth implant in the esthetic zone: A case report. Kaohsiung J Med Sci 2011;27:80-4.

40. Moon JW, Choi BJ, Lee WH, An KM, Sohn DS. Reconstruction of atrophic anterior mandible using piezoelectric sandwich osteotomy: A case report. Implant Dent 2009;18:195-202.

41. Ahn MR, An KM, Choi JH, Sohn DS. Immediate loading with mini dental implants in the fully edentulous mandible. Implant Dent 2004;13:367-72.

42. Schwartz-Arad D, Ofec R, Eliyahu G, Ruban A, Sterner N. Long term follow-up of dental implants placed in autologous onlay bone graft. Clin Implant Dent Relat Res 2016;18:449-61.

43. Aghaoloo TL, Moy PK. Which hard tissue augmentation techniques are the most successful in furnishing bony support for implant placement? Int J Oral Maxillofac Implants 2007;22 (Suppl):49-70.

44. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. Int J Oral Maxillofac Implants 2009;24 (Suppl):237-59.

45. Balbi Tj, Wolinger GJ, Petropoulos VC. Quadruple zygomatic implant support for retrieval of resorbed iliac crest bone graft transplant. implant Dent 2003;12:47-53.

46. Matomedian SR, Khojaste M, Khojaste A. Success rate of implants placed in autogenous bone blocks versus allogeneic bone blocks: A systematic literature review. Ann Maxillofac Surg 2016;6:78-90.

47. Shimono K, Oshima M, Arakawa H, Kimura A, Nawachi K, Kuboki T. The effect of growth factors for bone augmentation to enable dental implant placement: A systematic review. Jpn Dent Sci Rev 2010;46:43-53.

48. Chiapasco M, Romeo E, Vogel G. Tridimensional reconstruction of knife-edge edentulous maxillae by sinus elevation, onlay grafts, and sagittal osteotomy of the anterior maxilla: Preliminary surgical and prosthetic results. Int J Oral Maxillofac Implants 1998;3:394-9.

49. Anitua E. Plasma rich in growth factors: Preliminary results of use in the preparation of future sites for implants. Int J Oral Maxillofac Implants 1999;14:529-35.

50. Peleg M, Mazor Z, Gany AK. Augmentation grafting of the maxillary sinus and simultaneous implant placement in patients with 3 to 5 mm of residual alveolar bone height. Int J Oral Maxillofac Implants 1999;14:549-56.

51. You TM, Choi BH, Zhu SJ, Jung JH, Lee SH, Huh JY, et al. Platelet-enriched fibrin glue and platelet-rich plasma in the repair of bone defects adjacent to titanium dental implants. Int J Oral Maxillofac Implants 2007;22:417-22.

52. Sjöström M, Sennerby L, Nilson H, Lundgren S. Reconstruction of the atrophic edentulous maxilla with free iliac crest grafts and implants: A 3-year report of a prospective clinical study. Clin Implant Dent Relat Res 2007;9:46-59.

53. Lundgren S, Cricchio G, Palma VC, Salata LA, Sennerby L. Sinus membrane elevation and simultaneous insertion of dental implants: A new surgical technique in maxillary sinus floor augmentation. Periodontol 2000 2000;2008:47:193-205.

54. Hernández-Alfaro F, Sancho-Puchades M, Guijarro-Martínez R. Total reconstruction of the atrophic maxilla with intraoral bone grafts and biomaterials: A prospective clinical study with cone beam computed tomography validation. Int J Oral Maxillofac Implants 2013;28:241-51.

55. Sohn DS, Heo JU, Kwak DH, Kim DE, Kim JM, Moon JW, et al. Bone regeneration in the maxillary sinus using an autologous fibrin-rich block with concentrated growth factors alone. Implant Dent 2011;20:389-95.