



Evaluation of Bone Stability and Esthetic Results After Immediate Implant Placement Using a Novel Synthetic Bone Substitute in the Anterior Zone: Results After 12 Months



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The aim of this study was to assess bone and soft tissue changes after tooth extraction and immediate implant insertion in the anterior maxilla. A novel synthetic bone graft (VivOss, Straumann) was used to fill the gap between the implant surface and the alveolar bone. Implants with a reduced diameter compared to the size of the socket were used. A fixed or removable provisional restoration was provided immediately after implant placement. Cone beam computed tomography (CBCT) scans were taken to evaluate bone changes, showing minor variations after 12 months of follow-up. To evaluate soft tissue changes, clinical vertical measurements were performed. Based on the results obtained from 15 implants placed in 14 patients, it can be concluded that the use of an immediate implant in combination with a synthetic bone graft and immediate provisionalization seems to be a predictable treatment option with satisfactory esthetic results after 1 year. Int J Periodontics Restorative Dent 2018;38:235–243. doi: 10.11607/prd.2863

Immediate implant therapy is a very attractive treatment option for the patient as it reduces the number of visits and treatment time and can reduce treatment costs and postoperative complications.^{1–5} However, clinicians should consider immediate implant therapy a technically sensitive approach. It may be challenging even for highly experienced clinicians to place the implant in the prosthetically correct position in a postextraction socket.⁶ An inappropriate implant placement may lead to biologic and esthetic complications.⁷ For these reasons, the clinician performing immediate implant treatment must take into account the healing of a socket after tooth extraction, and especially the alveolar healing in the anterior zone. This remodeling process has been widely described in the literature. After tooth extraction, a substantial decrease in the bone volume toward the palatal aspect of up to 50% during the first 12 months was reported.^{5,8–10} More accentuated changes after tooth extraction are expected with decreasing buccal bone thickness.¹¹ The majority (62.9%) of maxillary teeth from bicuspid to bicuspid demonstrate buccal bone plate thickness of < 1 mm.¹² Thus, the immediate implant should be placed away from the buccal bone, creating a space at the facial aspect of the implant.³ Animal and human

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studies suggest the use of a bone graft in this space.^{8,13–15} Clinical data is available on different materials, but to date there is no clear evidence for the superiority of one biomaterial over any others. In the present clinical study, a newly developed synthetic biphasic calcium phosphate graft material (VivOss, Straumann)¹⁶ was used to fill the gap.

The primary aim of this prospective clinical study was to evaluate the potential of the synthetic bone graft to minimize the bone remodeling after tooth extraction in immediate implants in the esthetic zone. In addition, the study aims to establish a relationship between bone remodeling and changes in soft tissues.

Materials and Methods

A total of 15 implants placed in 14 patients were included in this study with 1-year follow-up.

The implants were placed in the esthetic zone in the anterior maxilla. All patients required single tooth extraction due to advanced caries lesions, periodontally hopeless teeth, trauma/root fracture, or non-retractable endodontic failure. The study was conducted after receiving approval from the Ethics Committee of Clinical Investigation of the Universitat Internacional de Catalunya. After explaining the possible treatment options and requirements for participation in the study, patients who signed the informed consent were subjected for study eligibility. The inclusion criteria applied to this study were as follows:

- Healthy subjects aged 20 to 75 years
- A hopeless single tooth in the maxillary anterior region (incisor, canine, or premolar)
- Intact socket walls after tooth extraction
- Absence of dehiscence in the 4 mm most coronal of the buccal bone
- Medium-thick soft tissue biotype
- Sufficient apical bone to allow adequate anchorage/primary stability of the implant (4 to 5 mm)

Patients who presented the following characteristics were excluded from the study:

- Presence of acute infection
- Damaged buccal bone wall after tooth extraction
- Impossibility of reaching adequate implant primary stability in the native bone
- Need for surgical flap to place the implant or to regenerate the bone
- Smokers of > 10 cigarettes per day
- Antitumor chemotherapy or radiotherapy in the previous year
- Unwillingness to sign the informed consent

Full-mouth Plaque Index and full-mouth bleeding on probing were recorded for all enrolled patients. All patients were treated by the same clinician (A.B.P).

Before surgical treatment, a periapical radiograph and a cone beam

computed tomography (CBCT) scan of the hopeless tooth were performed for diagnosis and treatment planning. A cast model was prepared to make the surgical stent and elaborate an adhesive provisional restoration.

Surgical Protocol

Local anesthesia was induced by infiltration with articaine with adrenaline 1:100,000. Hopeless teeth were carefully extracted, and the presence of an intact buccal bone was checked with a periodontal probe. Straumann Bone Level Roxolid SLActive implants with a diameter of 3.3 or 4.1 mm were placed in the extraction socket without raising a mucoperiosteal flap (Fig 1).

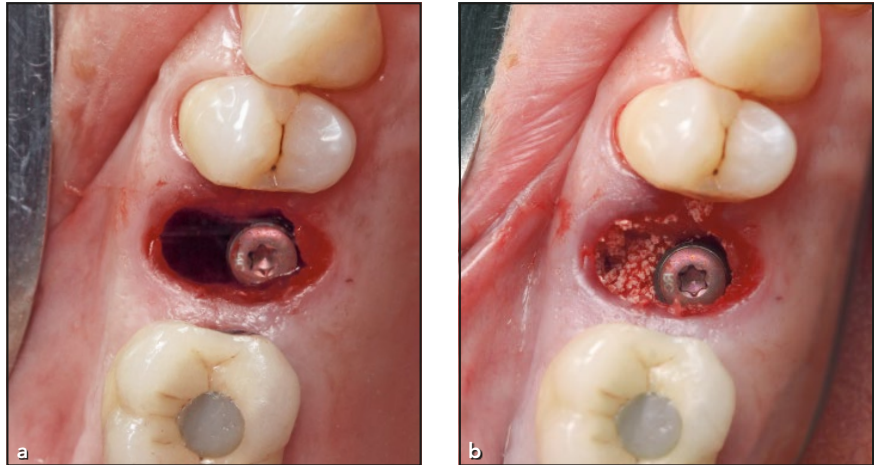
Implant diameter was chosen based on the size of the socket, to avoid intimate contact with the buccal bone plate, and on the mesiodistal space of the edentulous zone. Different implant lengths (10, 12, and 14 mm) were used to reach an adequate primary stability. The implants were positioned slightly to the palatal side according to the surgical stent, creating a space between the buccal bone wall and the implant. The gap was filled with a novel synthetic bone graft, composed of 10% hydroxylapatite and 90% beta-tricalcium phosphate (VivOss, Straumann). No sutures were used (Fig 2).

Regarding the apicocoronal positioning of the implant, the buccal alveolar bone peak was used as a reference point. The implant shoulder was placed 1 to 2 mm apical to this point.



Fig 1 (top) Hopeless teeth were extracted carefully (a,b) and implants were placed immediately using a flapless approach (c).

Fig 2 (right) The implants were placed toward the palatal bone, creating a space on the buccal side of the implant (a), which was filled with the novel synthetic bone substitute (b).



All patients were prescribed amoxicillin 750 mg for 7 days after surgery, anti-inflammatories and analgesic medication for 4 to 5 days (ibuprofen 600 mg), and 0.12% chlorhexidine mouthrinse for 7 days after intervention twice a day.

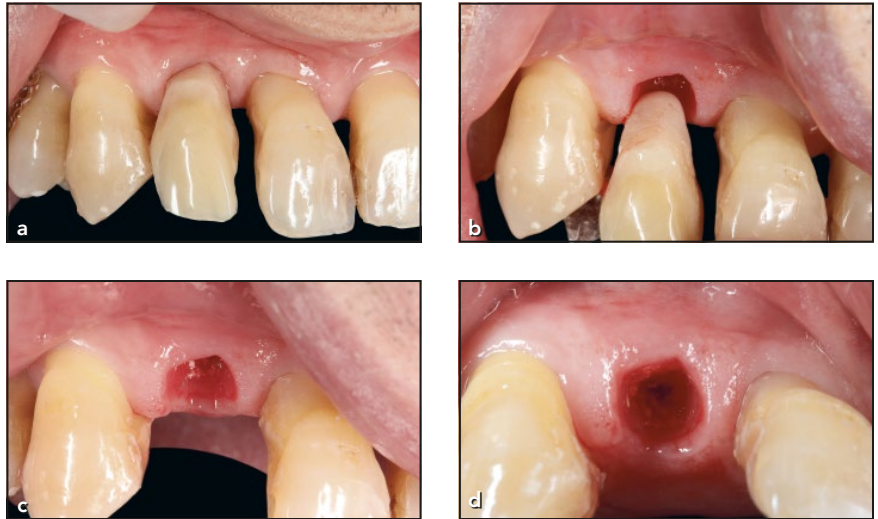


Fig 3 The immediate adhesive provisional offered support to the soft tissues just after the extraction and immediate implant placement, and prevented loss of the bone substitute (a,b). The gingival architecture was maintained by the fixed provisional (c,d).

Prosthetic Procedures

An adhesive, tooth-supported provisional restoration, prepared by the laboratory, was immediately provided to the patient and cemented to the palatal surfaces of the neighboring teeth. In cases where the overbite was unfavorable or the neighboring teeth had ceramic restorations with difficult adhesion conditions, a partial acrylic removable denture without buccal flange was used. The provisional restorations were in close contact with the sock-

et, which avoided the loss of the bone graft and supported the soft tissues immediately postextraction. Great effort was made to warrant a polished surface of the resin in con-

tact with the soft tissues to avoid adverse effects (Figs 3 and 4).

After 4 weeks of healing, the gingival part of the provisional restoration was modified by adding resin



Fig 4 In cases where an adhesive provisional restoration was not possible (a), an acrylic removable partial denture was adapted to maintain the bone substitute in the gap and give support to the soft tissues (b,c).



Fig 5 The provisional restoration (a) was used to expose the head of the implant (b) and create the adequate emergence profile (c). Resin was added in increments on the gingival part until the healing cap of the implant was exposed (d,e).



composite until the closure cap of the implant was exposed. The resin increments were 1 to 1.5 mm per vis-

it; after two or three visits the implant was exposed and an adequate emergence profile was created (Fig 5).

Definitive impressions were taken between 6 and 10 weeks after implant placement. On average, after 8 weeks the implants were exposed and impressions were taken. A customized zirconia abutment was fabricated. The ideal anatomy of the cementable abutment was waxed up by the laboratory technician. The model was scanned and computer-assisted manufactured in zirconia with a metal interphase. These two elements were cemented extra-orally with Rely X Unicem (3M ESPE). Finally, a full-ceramic crown was cemented onto the zirconia abutment using a retraction cord to avoid sub-gingival cement extrusion (Fig 6).

Clinical and Radiographic Outcome Measurements

To assess the bone stability after implant treatment, CBCT scans (Kodak 9000 3D, Carestream Health) were taken just after tooth extraction and immediate implant placement and after 12 months of follow-up (Fig 7). To minimize patients' exposition to unnecessary radiation, a reduced field of view was applied according to implant position. Five horizontal measurements were taken with the implant shoulder as a reference

Fig 6 A customized zirconia abutment was elaborated (a), and a full ceramic crown was cemented (b).

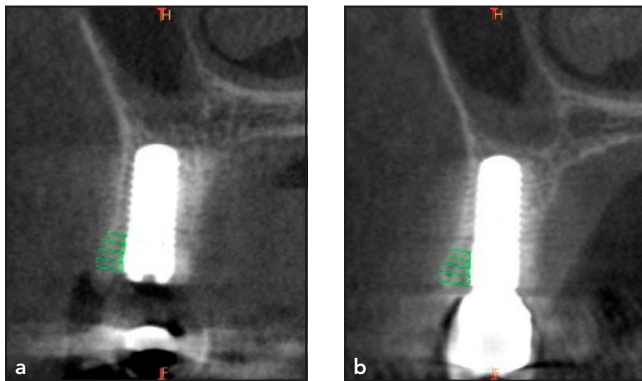
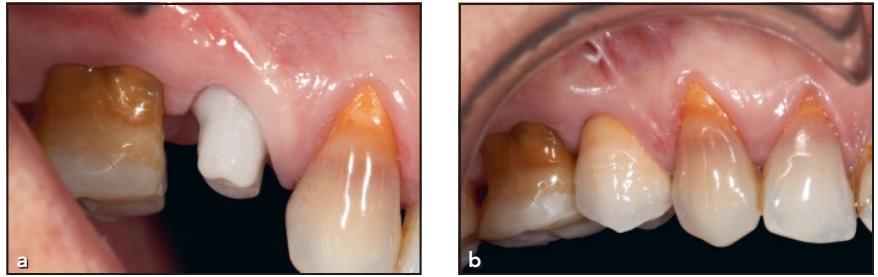


Fig 7 Five horizontal measurements were taken on the CBCT just after implant insertion (a). The same measurements were repeated after 12 months (b).

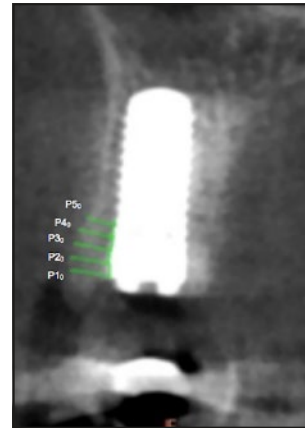


Fig 8 The five horizontal measurements from the implant platform to 5 mm below after implant placement.

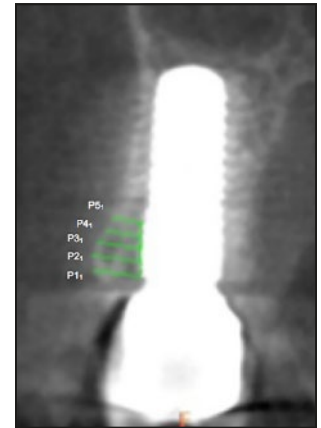


Fig 9 The five horizontal measurements from the implant platform to 5 mm below 12 months after implant placement.



Fig 10 Three vertical clinical measurements were taken to evaluate changes in soft tissues: (a) from occlusal/incisal surface to the most coronal point of the mesial papilla, (b) from occlusal/incisal surface to the most coronal point of the distal papilla, and (c) from occlusal/incisal surface to the highest point (zenith) of the gingival margin.

point. The measurements were performed from the buccal surface of the implant to the most vestibular point of bone (Figs 8 and 9).

The soft tissue changes were evaluated by three vertical measurements on the day of the final restoration delivery and compared to

the same measurements taken 12 months after (Fig 10).

Results

Of the patients, 10 were women and the other 4 were men. The average

age was 57.5 years (range: 33 to 69 years). A total of 15 implants were placed. One was placed in position of a central incisor, 4 on lateral incisors, 3 first premolars, and 7 second premolars.

All implants were osseointegrated and in function 12 months

Table 1 Quantity of Bone (in mm) at the Labial Part of the Implant at Baseline and 12 Months

Implant	P1 ₀	P1 ₁	P2 ₀	P2 ₁	P3 ₀	P3 ₁	P4 ₀	P4 ₁	P5 ₀	P5 ₁
1	2.9	0	2.9	1.8	2.9	2.0	2.6	1.8	2.2	1.6
2	3.2	2.8	3.1	2.9	2.7	2.5	2.6	2.1	2.4	2.1
3	2.2	0	2.9	2.5	2.9	2.8	2.9	2.9	2.8	2.8
4	2.8	2.6	2.4	2.4	2.0	2.0	1.9	1.5	1.6	1.1
5	2.8	2.5	2.7	2.7	2.6	2.6	2.3	2.2	1.8	1.8
6	5.7	5.5	6.3	5.7	6.3	6.3	6.7	6.5	6.5	6.4
7	4.6	3.3	3.6	3.3	3.2	3.0	2.7	2.6	2.6	2.6
8	2.7	2.0	2.7	1.9	2.7	1.9	2.7	1.9	2.6	1.8
9	4.4	4.1	4.2	4.1	4.2	3.9	4.4	4.0	4.0	3.9
10	3.1	3.0	3.0	2.8	2.9	2.7	2.7	2.7	2.9	2.8
11	6.7	5.7	6.3	5.4	6.0	5.0	5.7	4.4	5.1	4.1
12	3.5	2.0	3.3	2.5	3.3	2.3	3.3	2.3	3.6	2.2
13	4.9	4.5	4.7	4.2	4.5	4.0	4.0	3.8	4.0	3.6
14	3.3	2.3	3.2	2.3	3.0	2.1	3.0	1.8	3.0	1.6
15	2.6	1.4	2.5	1.6	2.0	1.1	1.9	1.1	1.7	0.9
Average	3.69	2.78	3.58	3.07	3.41	2.94	3.29	2.77	3.12	2.62

P1₀ = baseline measurement at the implant platform; P1₁ = measurement after 12 months at the implant platform; P2₀ = baseline measurement 1 mm below implant platform; P2₁ = measurement after 12 months 1 mm below implant platform; P3₀ = baseline measurement 2 mm below implant platform; P3₁ = measurement after 12 months 2 mm below implant platform; P4₀ = baseline measurement 3 mm below implant platform; P4₁ = measurement after 12 months 3 mm below implant platform; P5₀ = baseline measurement 4 mm below implant platform; P5₁ = measurement after 12 months 4 mm below implant platform.

Table 2 Bone Changes (in mm) at the Labial Part of the Implant Between Baseline and 12 Months

Implant	Tooth position (FDI)	P1	P2	P3	P4	P5
1	22	-2.9	-1.1	-0.9	-0.8	-0.6
2	12	-0.4	-0.2	-0.2	-0.5	-0.3
3	14	-2.2	-0.4	-0.1	0	0
4	15	-0.2	0	0	-0.4	-0.5
5	25	-0.2	0	0	-0.1	0
6	25	-0.2	-0.6	0	-0.2	-0.1
7	11	-1.3	-0.3	-0.2	-0.1	0
8	24	-0.7	-0.8	-0.8	-0.8	-0.8
9	25	-0.3	-0.1	-0.3	-0.4	-0.1
10	12	-0.1	-0.2	-0.2	0	-0.1
11	25	-1	-0.9	-1	-1.3	-1
12	15	-1.5	-0.8	-1	-1	-1.4
13	25	-0.4	-0.5	-0.5	-0.7	-0.4
14	22	-1	-0.9	-0.9	-1.2	-1.4
15	14	-1.2	-0.9	-0.9	-0.8	-0.8
Average		-0.9	-0.51	-0.46	-0.55	-0.5

P1 = measurement at implant platform; P2 = measurement 1 mm below the implant platform; P3 = measurement 2 mm below the implant platform; P4 = measurement 3 mm below the implant platform; P5 = measurement 4 mm below the implant platform.

after placement. Therefore, implant survival 1 year after implant placement was 100%.

After 12 months, all implants had on average > 2 mm of bone at the vestibular site as measured in the CBCT analysis, ranging from 3.07 mm at 1 mm below the implant platform to 2.62 mm at 4 mm below (Table 1). For implants 1 and 3, an absence of bone was observed at the most coronal point with a considerable reduction compared to the baseline values of 2.9 and 2.2 mm, respectively (Table 1). Although all implants showed adequate bone volume at the buccal site, bone change, defined as difference in bone level between baseline and 12 months, was observed in all measurements. The values presented in Table 2 indicate the bone changes after 12 months at five different points of the implant. It can be observed that the major bone changes occurred at the most coronal point of the implant: 0.9 mm of bone reduction was observed at the implant platform.

After 12 months, the clinical measurements revealed soft tissue creeping at the three measured aspects: mesial papilla, zenith of the gingival margin, and distal papilla (Table 3). The mesial papilla had an average improvement of 0.3 mm. Similarly, an average improvement of 0.25 mm was found in the zenith of the gingival margin, except at implant 14 where 0.5 mm of recession was detected. An average creeping of the soft tissues of 0.2 mm was found at the level of the distal papilla, except for implant 6, where it decreased by 0.5 mm (Table 3).

Discussion

After tooth extraction, a certain degree of bone remodeling should always be expected. So far, no mechanisms have been described to avoid the collapse of the socket after tooth loss, but there are clinical procedures that can minimize the remodeling of the alveolar walls.¹⁷ The most pronounced changes occur in the buccal part of the socket due to the presence of the bundle bone.¹⁸ It was previously reported that placing the implant immediately after tooth extraction helped to minimize bone changes,¹⁹ but this concept has not been confirmed by further clinical and animal studies. Despite these findings, favorable esthetic results after immediate implant placement and provisionalization have been reported.^{18,20} However, recession of the facial soft tissue was also described in retrospective studies with a long-term follow-up.^{4,21,22} This is clearly related to the presence of bone in the buccal aspect of the implant, supporting the idea that maintenance of the soft tissues depends on the underlying bone.²¹

In the present study, different strategies were applied to ensure an appropriate quantity of bone on the buccal site of the implant to enhance the stability of the soft tissue. Implants with a reduced diameter in comparison to the size of the socket were placed in a palatally oriented position. Following this protocol, a gap was created between the implant and the inner part of the buccal bone wall of the socket. The use of a bone graft to fill this gap has been recommended in

Table 3 Vertical Changes (in mm) of Soft Tissues After 12 Months

Implant	Mesial papilla	Gingival margin	Distal papilla
1	-1	-0.5	-0.5
2	0	0	0
3	-0.5	-0.5	-0.5
4	0	0	-0.5
5	0	0	-1
6	-0.5	0	0.5
7	-0.5	0	0
8	-0.5	0	0
9	-0.5	-0.5	-1
10	-0.5	-1	0
11	0	0	0
12	0	0	0
13	-0.5	0	0
14	0	0.5	0
15	0	0	0
Average	-0.3	-0.25	-0.2

the literature based on clinical and animal studies.^{3,8,13} Different biomaterials have been used, but so far none of the bone grafts has been shown to be superior over another in this indication. In the present prospective clinical study, a newly developed material was used (VivOss, Straumann). This material has been considered to have osteoconductive and osteoinductive properties.^{16,23} A flapless approach was used to limit the degree of invasiveness and to prevent bone remodeling.

After 1 year, the 14 subjects in the present study completed the follow-up. Adequate osseointegration and buccal bone width could be observed in the CBCTs. The three-dimensional radiologic examinations showed the lowest average bone thickness at the most apical measurement, while greater bone changes were detected at the most

coronal point, at the level of the implant platform. This may be explained by the fact that for cases 1 and 3 the implants were not placed sufficiently below the crest. Thus, this region is the first to be affected by vertical resorption of the buccal bone plate and leaves the most coronal surface of the implant exposed to the soft tissues (Tables 1 and 2). The average bone reduction at the level of the implant platform was 0.9 mm (Table 1). This value is comparable to those reported by Degidi et al¹⁵ in 2012 using a xenograft to fill the gap around immediately placed implants following a flapless technique. After 1 year of follow-up, an average bone change of 0.88 mm was reported, which corresponds to the height of the implant platform.¹⁵ In 2014, Lee et al²⁰ reported 0.12 ± 0.22 mm of bone reduction after 6 months of follow-up, also using

a xenograft.²⁰ Using an allograft as bone substitute, Spinato and Galino-Moreno²⁴ reported a horizontal reduction of 0.62 mm after 12 months of follow-up.

When the quantity of bone present at the buccal part of the implant was analyzed, the results of the present study were better than those reported by Miyamoto and Obama⁴ in 2011 using autologous bone graft to fill the buccal gap in immediately placed implants in the esthetic zone. They showed an average bone width at the implant platform level of 0.48 mm after a mean follow-up of 31 months. In the present study, using a synthetic bone graft, the quantity of bone at this level was 2.78 mm after 12 months (Table 2). These results are very similar to those obtained using xenograft: 2.08 mm after 6 months²⁰ or 2.12 mm after 12 months.¹⁵ Spinato and Galindo-Moreno²⁴ reported an average bone width of 1.19 mm after 12 months, using allograft to fill the gap.²⁴ The difference in results with regard to the bone volume in the buccal part of the implant may be further influenced by the heterogeneity of the surgical and prosthetic protocols.

Providing the patient with an immediate provisional restoration, either fixed or removable, prevented the loss of the bone graft into the oral cavity and supported the soft tissue immediately after tooth extraction.

After 12 months, the position of the soft tissue at the mesial papilla, the zenith of the gingival margin, and the distal papilla had improved. The highest improvement was observed at the mesial papilla (Table 3).

Conclusions

Dimensional bone changes should be expected after tooth extraction. Within the limits of this study, it was demonstrated that the most pronounced bone remodeling occurred in the most coronal part of the crest. Immediate insertion of an implant after tooth extraction using a flapless technique in combination with a synthetic bone graft and immediate provisionalization seems to be a predictable treatment option showing favorable esthetic results after 1 year of follow-up. However, further studies with a longer follow-up are needed to confirm this outcome.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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