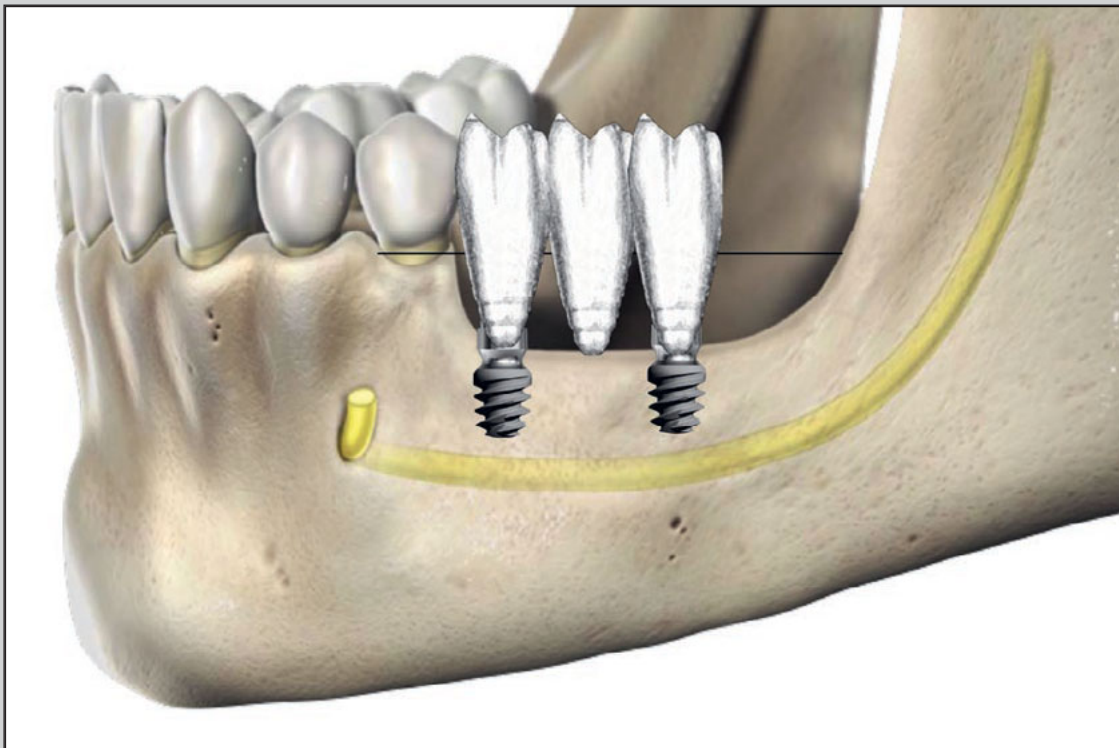
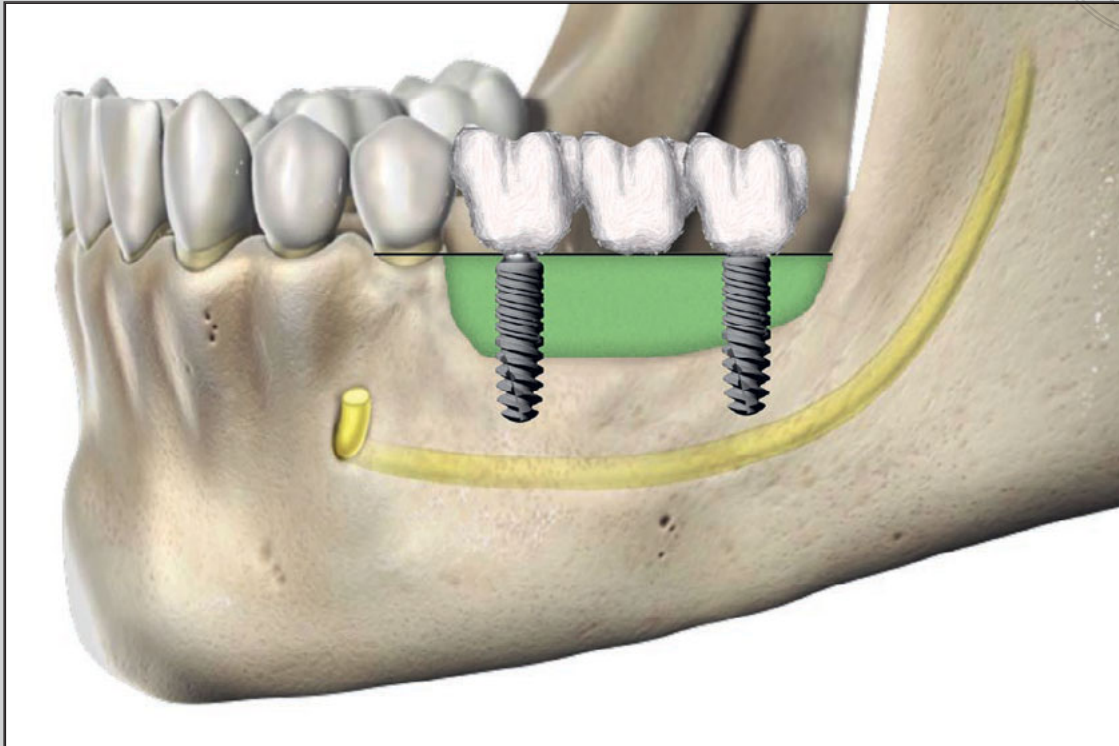
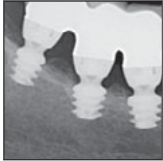




Decision Criteria Proposed for the Treatment of Vertical Bone Atrophies in the Posterior Mandible



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In everyday practice, surgeons have to deal with bone atrophy. These rehabilitations are even more complex in the posterior mandible, and it is still unclear in the literature which fixed rehabilitation option is best. The purpose of this article was to help oral surgeons to choose the proper and updated treatment for their atrophic patients. Posterior mandible bone atrophies were divided into four main groups depending on the bone height measured above the inferior alveolar nerve: (1) ≤ 4 mm; (2) > 4 mm ≤ 5 mm; (3) > 5 mm ≤ 6 mm; (4) > 6 mm < 7 mm. Different approaches were proposed for each group, considering patient expectations. If ≤ 4 mm of bone height was available, guided bone regeneration was used as the adequate approach. For bone heights > 4 mm and ≤ 6 mm, the "sandwich" technique and/or short implants were used, depending on esthetics. In cases with > 6 mm and < 7 mm above the mandibular canal, short implants might be the proper option. The authors' clinical experience and the literature were considered in order to suggest a possible correct treatment decision based on the residual bone height in the posterior mandible. *Int J Periodontics Restorative Dent* 2021;41:71–77. doi: 10.11607/prd.4922

In daily practice, oral surgeons have to solve a large number of clinical problems related to the placement of implants for a fixed prosthetic rehabilitation.¹ Nonatrophic clinical situations (≥ 7 mm of residual bone height) are generally not a big task, as long implants can be placed without any reconstructive surgery nowadays. On the other hand, fixed rehabilitations in posterior atrophic arches could be challenging, especially in the mandible due to the proximity of the inferior alveolar nerve.² In these cases, various surgical approaches have been proposed to vertically augment the posterior atrophic mandible, such as interpositional block bone graft,³ guided bone regeneration (GBR),⁴ alveolar distraction osteogenesis,⁵ and onlay graft techniques.^{6–8} However, according to the existing systematic reviews, it is still unclear which is the most effective option. As a consequence, the surgeon generally chooses the technique they are more familiar with. Moreover, these procedures could be associated with clinical complications, require long rehabilitative periods, and tend to be expensive.² However, these reconstructive approaches may provide a good final esthetic outcome.

As an alternative, short implant placement can avoid bone grafting, thus reducing rehabilitative times, surgical complications, and costs.^{9–15}

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Table 1 Decision Criteria Proposed for the Treatment of Vertical Bone Atrophies in the Posterior Mandible

Residual bone height	Reconstructive surgery	Use of native bone	Implant surgery	Esthetic crown height
≤ 4 mm	GBR	No	Long implants	Inadequate
> 4 mm ≤ 5 mm	"Sandwich" technique	No	Long implants	Adequate
	No	Yes	Short implants (4 mm)	Inadequate
> 5 mm ≤ 6 mm	"Sandwich" technique	No	Long implants	Adequate
	No	Yes	Short implants (5 mm)	Inadequate
> 6 mm < 7 mm	No	Yes	6-mm implants	Adequate/ Inadequate

GBR = guided bone regeneration.

In this regard, many questions related to implant rehabilitation in the atrophic posterior mandible remain open, in particular: (1) What rehabilitative treatment should be chosen for different levels of atrophy in the posterior mandible? (2) In which clinical situations is it advisable to carry out augmentation procedures in order to place long implants? (3) When should the oral surgeon choose a short implant instead?

Decision Criteria

To decide on an adequate treatment choice, it is necessary to clinically and radiographically evaluate the bone atrophy type. In order to obtain more accurate data on the residual bone height above the mandibular canal, it is best to perform a preoperative CBCT scan. Possible surgical approaches were proposed according to the different bone heights above the in-

ferior alveolar nerve: (1) ≤ 4 mm; (2) > 4 mm ≤ 5 mm; (3) > 5 mm ≤ 6 mm; (4) > 6 mm < 7 mm (Table 1).

However, the residual bone height is not the only factor to be considered. Of great importance is also the residual width. According to the authors, the native bone width could be generally sufficient with at least 2 mm of peri-implant bone thickness.

Another important factor emerging from the literature is the presence of keratinized tissue (KT). Having 2 mm of KT around the implant shoulder seems to be important to maintaining peri-implant tissue health, adequate esthetics, and good plaque control without brushing discomfort. Areas with KT greater than 2 mm could accumulate less plaque, which in turn prevents inflammation that can lead to peri-implantitis and implant failure.¹⁶

Moreover, less invasive surgeries are routinely preferred for patients with systemic diseases not contraindicating surgery. For these

cases, based only on their clinical experience, the present authors recommend avoiding reconstructive approaches favoring short implants in these cases, as complication rates tend to increase.

The present article combines literature results with the authors' personal experience in order to help surgeons choose an adequate treatment plan for the fixed rehabilitation of the posterior atrophic mandible.

Residual Bone Height Above the Mandibular Canal

≤ 4 mm

In the presence of ≤ 4 mm of residual bone height, the authors consider the GBR technique with nonresorbable titanium-reinforced membranes to be the better treatment option. GBR was proposed in order to reconstruct bone by using grafts and a barrier to allow mechanical exclusion of undesirable soft tissue, favoring osteogenic cell

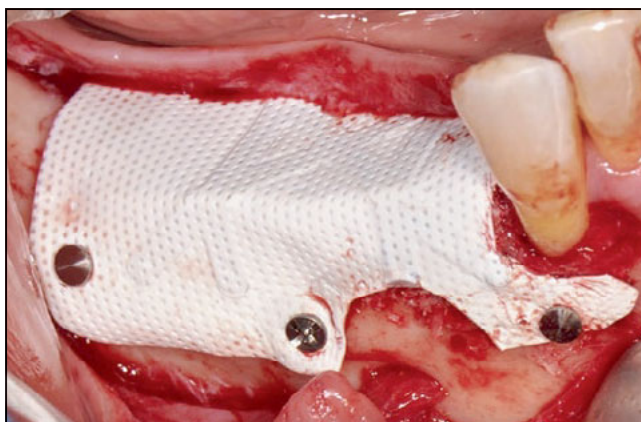


Fig 1 Example of a GBR approach. The nonresorbable titanium-reinforced membrane was used to stabilize a particulated bone graft in order to vertically augment a posterior atrophic mandible.

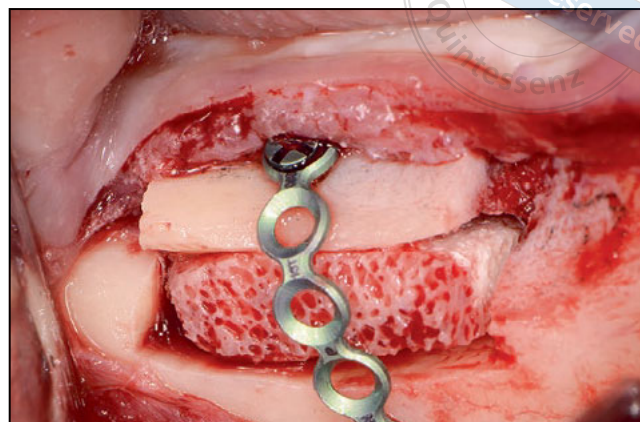


Fig 2 Example of an interpositional block bone technique. An osteotomized mandibular bone segment was lifted in order to position a xenograft stabilized with a miniplate and miniscrews.

growth in the osseous defect¹⁷ (Fig 1). The success of this technique could be influenced by the intrinsic characteristics of the mandibular bone rather than the flap management.¹⁸ The ability of the defect to vascularize the graft material, obtaining a biologically active bone (a regenerated bone that lasts over time), is limited in the posterior mandible. As a consequence, when performing GBR in this area, the bone height should be restricted to a maximum of 6 mm according to the literature. From a practical point of view, this means that the greater the vertical increase, the more the possibility of obtaining biologically active bone is reduced due to the distance of vascularization from the basal site to the graft.¹⁹ In a study by Troeltzsch et al, the authors advise against increases of more than 4 to 5 mm in vertical reconstructions.²⁰ Moreover, according to Urban et al, the highest increase suggested in vertical bone augmentation with GBR is 5.45 mm.²¹ These results are confirmed in a retrospective study

on GBR technique in 122 implants with a 3- to 7-year follow-up, where no more than 6 mm of augmentation was advised in order to obtain a vascularized and stable bone over time.¹⁹ A possible solution to this problem is performing a first GBR procedure to increase bone height by 6 mm and, once biologically active bone is obtained, conducting a second GBR procedure to reach the final needed height. However, it is necessary to take into account the increased risk of failure and complications, the longer rehabilitation period, and the greater financial burden on the patient. Complications from GBR are generally related to membrane exposure, which has a negative influence on the total amount of regenerated tissue.²² Yet, without GBR, it is almost impossible to place even the shortest implant (4 mm) without the risk of damaging the lower alveolar nerve.

If the GBR procedure is successful, the prosthetic rehabilitation with crowns of esthetic length will be a positive outcome for the patient.

> 4 mm ≤ 5 mm

This type of atrophy can be frequently seen and is often a borderline situation. The choice of treatment option is between performing a reconstructive surgery and using an ultrashort implant (4 mm long).

As there is still no literature evidence on the best reconstructive technique, the present authors suggest utilizing the interpositional block bone graft to vertically augment the atrophic posterior mandible. This approach involves lifting a coronal osteotomized segment of the mandible, which is still attached to the lingual periosteum, and the subsequent interposition of a block bone graft (Fig 2). This technique seems to guarantee a greater vascular supply, coming from the lingual periosteum and the residual bone to the internal graft; it also allows optimum use of the native basal bone, which should be less prone to resorption around the implant neck. Moreover, implant survival rate in bone augmented with the inlay technique after a 4.2-year

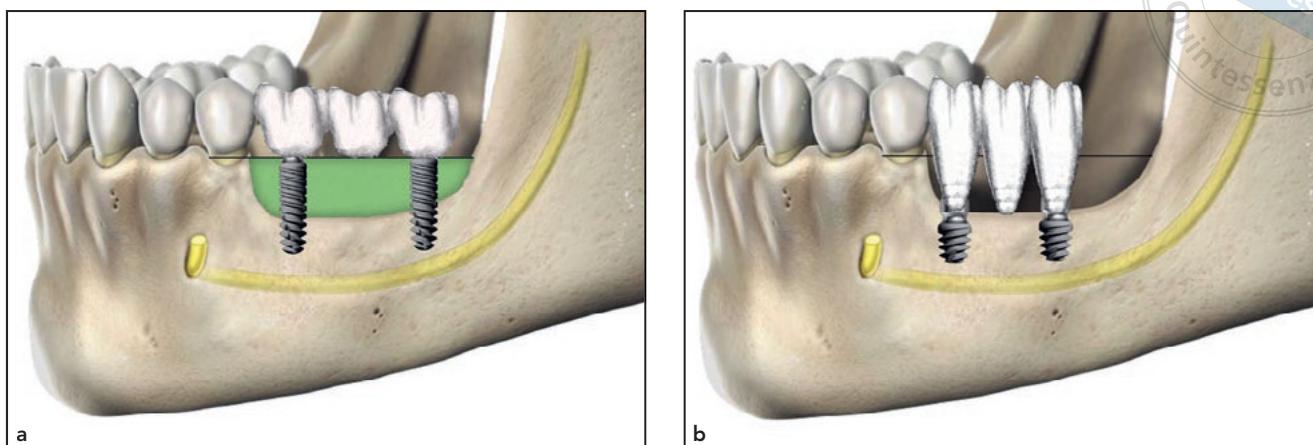


Fig 3 Illustrations showing the comparison between long implants in augmented bone and 4-mm super-short implants from an esthetic point of view. (a) Long implants in augmented bone with adequate crown length. (b) Super-short (4 mm long) implants with a longer crown compared to natural teeth.

mean follow-up ranges from 91.1% to 96.0%, with a favorable peri-implant marginal bone loss (1.37 mm after 7 years of loading) and bone height increase (5.75 mm) using xenografts.³ However, the “sandwich” technique can be used only for residual bone heights > 4 mm; otherwise, the chances of damaging the nerve²³ and fracturing the osteotomized segment are high. In cases of ≤ 4 mm of residual height, the GBR technique with a mixture of autogenous bone and xenograft is indicated.

Another treatment strategy could be to exploit the only residual native bone by placing 4-mm super-short implants. As reported in a study by Bolle et al, 4.0-mm-long implants achieved similar results, if not better, and had fewer complications than longer implants in augmented arches at 1 year after loading,²⁴ according to Pistilli et al.²⁵

This clinical decision should be made in conjunction with the patient and their expectations for the

upcoming rehabilitation. There are some factors that can influence the choice of treatment strategy: If the patient requires good esthetics, reconstructive surgery can augment the bone tissue height, with final crowns of adequate length that are comparable to the natural teeth (Fig 3). However, the morbidity rate, rehabilitative times, and costs increase when reconstructive surgery is performed. Further, esthetics are not too relevant in the posterior mandible in most cases, as this area is not visible.

Above all, every option should be explained to the patient in order to find the most suitable treatment plan for every specific clinical situation.

> 5 mm ≤ 6 mm

Comparing this clinical situation to the previous one, a less severe degree of atrophy provides the potential to place short implants that are 1 mm longer (5 mm) on the basis of stronger literature evidence in recent years. Several randomized

controlled clinical trials (RCTs) compared 5-mm-long implants with longer ones placed in augmented bone using the interpositional technique.^{26,27} The results of one study²⁶ show more complications associated with longer implants at mandibular grafted sites: 17 augmented patients were affected by complications vs 9 patients treated with short implants. Further, in mandibles, 2 grafted patients were not prosthetically rehabilitated because of multiple complications, and three implants failed, whereas just 1 patient who received a short implant lost the implant and crown 2 years after loading. Moreover, longer implants showed a greater bone loss than short implants up to 5 years after loading (1.70 mm vs 1.22 mm).²⁶ Based on the outcomes of this and other RCTs, 5-mm short implants might be a preferable choice to bone augmentation, especially in posterior mandibles, as the treatment is faster, cheaper, and associated with less morbidity.^{27,28}

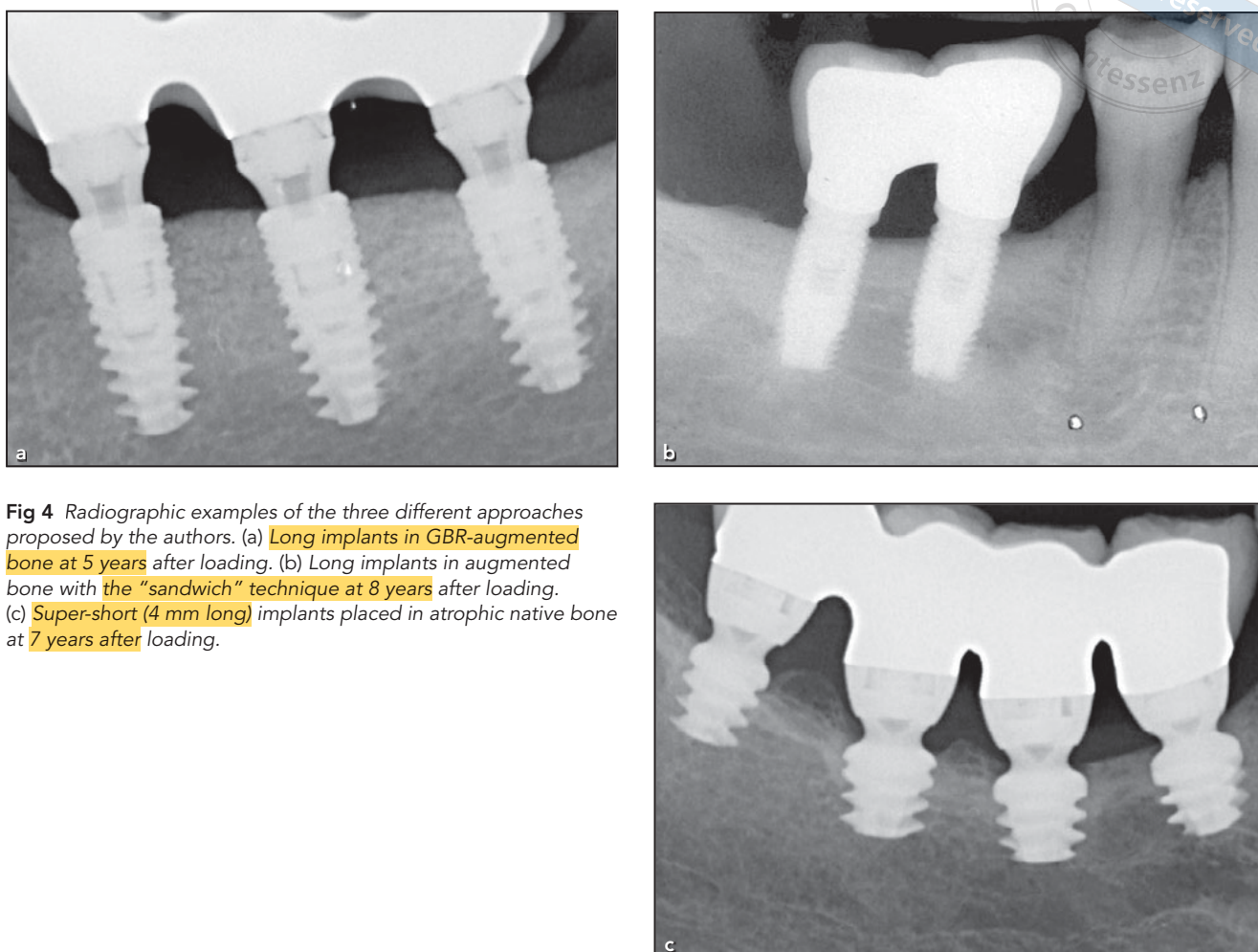


Fig 4 Radiographic examples of the three different approaches proposed by the authors. (a) Long implants in GBR-augmented bone at 5 years after loading. (b) Long implants in augmented bone with the “sandwich” technique at 8 years after loading. (c) Super-short (4 mm long) implants placed in atrophic native bone at 7 years after loading.

The interpositional technique could be considered an option only if the patient asks for better esthetics.

> 6 mm < 7 mm

The present authors currently suggest reconstructing the posterior mandible with a residual bone height > 6 mm and < 7 mm above the mandibular canal only if the patient refuses to place short implants, as described by Felice et al.²⁹ This split-mouth RCT evaluated whether 6-mm-long and 4-mm-wide implants could be an alternative to implants at least 10 mm long placed

in bone augmented with the inlay technique. More complications occurred at grafted sites, and patients with 6-mm-long implants lost an average of 1.34 mm of peri-implant bone at 5 years vs 2.11 mm in patients with longer implants.²⁹

Conclusions

When dealing with different levels of vertical atrophy of the posterior mandible, the surgeon has to decide which type of surgery is best for the subsequent fixed prosthetic

rehabilitation. When the residual bone height is ≤ 4 mm, the authors conclude that GBR is the best available technique. For heights > 4 mm to ≤ 6 mm, patient expectations and desires should guide the treatment plan: The interpositional technique could be a good solution in cases with high esthetic demands; otherwise, short implants could be recommended based on literature evidence. Indications for reconstructive surgery in less severe degrees of atrophy are very little, which is why short implants are becoming the first choice for the authors' everyday

practice. However, taking into account the individuality and systemic health condition of each patient, the surgeon's treatment choice should be determined based on the specific clinical situation and on their surgical experience (Fig 4).

The present suggestions (reflecting the authors' clinical experience and findings from the literature) should be further confirmed by longer follow-ups and a larger number of patients coming from RCTs. Moreover, the surgeons of the present study were experienced with the delivered **interventions**, which may limit **extrapolations** of the present results.

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