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# Success of bone grafts in atrophic posterior edentulous mandible: literature review

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***Background.*** **The success of implant therapy depends on the availability of an adequate bone volume in the edentulous site. In the case of posterior bone atrophy, the increase of the alveolar ridge is a prerequisite for the optimal placement of endosseous implants.**
**Purpose: The purpose of this research is to analyze in Literature the success of bone grafts in posterior atrophic edentulous mandible.**
***Materials and methods.*** **The Literature analysis includes only relevant articles specifically on the topic. The following parameters were evaluated: the type of materials used, the average gain expressed in millimeters, the success of the grafts over time and their complications, the outcome of the grafts according of the materials used and the survival rate of endosseous implants over time.**
***Results.*** **Autologous, homologous and heterologous materials were used for the grafts, either separately or in combination. However autologous bone, obtained from the mandible, was preferentially used for grafts in atrophic posterior mandible. Membranes could be also associated to the grafts. The gain in the alveolar ridge was achieved both horizontally and vertically, and usually reflected the surgeon's effort to meet patient's needs.**
***Conclusions.*** **A review of literature reveals that the intraoral autologous bone graft is the most used and allows to achieve the best result in restoring posterior atrophic mandible.**

**KEY WORDS:** Bone regeneration - Graft - Mandible.

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The alveolar process is formed during the development and eruption of the tooth and gradually fails when the tooth is lost. The edentulous determines the disappearance of the periodontium resulting in a volumetric shrinkage of the alveolar process of the maxilla. The teeth and periodontum (cementum, periodontal ligament and alveolar bone) form a functional unit. Therefore, the forces applied during mastication are transmitted from the crown to the root and the root to the alveolar bone which is then subjected to loads.[1]

The loss of the bone results in a series of adaptive changes of the remaining edentulous ridge. The dimensions of the alveolar ridge are markedly reduce, not only horizontally but also vertically and there is also a dimensional reduction of the overall dental arch.

These paraphysiological adaptations are a consequence of the change in the load transmitted by the muscles to jaw bones. Indeed in the presence of teeth, the force

applied during the contraction of chewing muscles is transmitted from the periodontal ligament to the bone in the form of stress-strain that stimulates the continuous remodeling of the alveolar process (Wolff).[2] After dental extraction the functional loading of the muscles is no long applied at endo-alveolar level but rather to the cortical surface of the bone baseline in the regions of muscles insertion. This change in stress-strain leads to the disappearance of the alveolar bone.

The alveolar ridge decreases markedly after removal of a single tooth. The magnitude of this change has been studied and reported by Pietrokovski and Massler.[3] The extent of resorption of tissues (hard, soft or of both types) after the loss of a single tooth was considerable, with a greater reduction of the ridge at the level of the buccal surface than the lingual and palatal ones.

As a result of this tissue remodeling, the center of the edentulous site moved towards the lingual or palatal face of the ridge.

The loss of a tooth is a pathological event considered of limited importance, often underestimated by both the clinician and the patient; however, the situation of total edentulism, which is the conclusion of a prolonged series of individual extractions, reduces the person in a dramatic condition: indeed chewing function is lost and phonetics and aesthetics are greatly compromised.

Oral implantology allows to rehabilitate the stomatognathic system.[4, 5] It also gives back to patients satisfactory masticatory and phonetic functions, while the improving of aesthetic contributes to restore self-confidence.

The resorption of the edentulous or partially edentulous alveolar ridges frequently affect the placement of endosseous implants in a prosthetically ideal position.[6, 7, 8]

The success of the implant therapy depends on the availability of a sufficient bone volume in the insertion site; the presence of an inadequate bone volume, in fact, affects long-term prognosis of dental implants.[9, 10]

The increase of the alveolar ridge is often a prerequisite for optimal placement of endosseous implants.[11]

Therefore, the increase of bone volume is often indicated before or simultaneously to the implant placement to obtain predictable results for the functional and aesthetic treatment.[6]

The progressive contraction of the alveolar ridge also leads to an increase of the inclination of the alveolar axis of the upper maxillary in vestibular sense and lingually in the lower jaw, this change increase the discrepancy between the bone axis and the ideal prosthetic axis. The purpose of the pre-prosthetic surgery is to reconstruct the skeletal and soft tissues scaffolding to allow the restoration of anatomical shape and the normal functions: mastication, phonetics and aesthetics.[2]

There could be different surgical techniques to increase the bone volume to restore an adequate bone anatomy. There could be expansive techniques (i.e. split crest), osteodistraction,[12, 13] dislocative techniques as dislocation of IAN (alveolar inferior nerve) [14], additive techniques as onlay graft, and mixed techniques (i.e. combination of graft and dislocation of IAN).

The selection of the most suitable surgical technique depends on the anatomical feature of the atrophic alveolar process and from the functional and aesthetical requirements.

In the future could be used increasing techniques of the alveolar bone that involve the use of stem cells.[15, 16, 17, 18, 19]

After the increasing procedure of the bone, oral implants could be inserted.

The endosseous osseointegrated implantology has among its advantages the ability to limit the resorption of the edentulous alveolar process.

## Purpose

The purpose of this review is to analyze in the available literature on human bone grafts in the atrophic posterior edentulous mandible the following endpoints:

1. difference in the choice of graft material;
2. survival of the graft;
3. surgical complication;
4. survival rate of endosseous implants on grafted bone.

## Materials and methods

The literature search was performed using as sources the databases of PubMed and UniVerSe (the latter of the University of Verona) by inserting as keywords for the research: *autologous bone graft, atrophic posterior mandible, onlay bone graft, alveolar ridge augmentation, augmentation of the atrophic edentulous, allogeneic, bone graft mandible, edentulous mandible, horizontal ridge augmentation, implant rehabilitation of the edentulous, vertical ridge augmentation, xenografts*.

The parameters used for the selection of the articles were:

— the site of the edentulous area, i.e. the posterior region of the mandible, were considered defects unilateral or bilateral;

— the need of an increase in bone thickness in vertical and/or horizontal;

— the presence of values expressed in millimeters of the gain in vertical and/or horizontal of the ridge;

— the presence of a follow-up over time of the grafts;

— articles that considered patients with conditions of good health, not subject to prior resection of tumors or radiation therapy.

The success of the graft is considered as the possibility to insert endosseous oral implants in grafted sites. The survival of the graft is considered as its persistence over time. The survival of the endosseus oral implants is considered as its persistence in grafted site over time and it is not observed any radiographic bone loss around the endosseus implants.

Parameters of observation were the survival rate of the grafts over time and possibility of endosseous implant placement in the grafted sites for fixed implant-prosthetic rehabilitation where it was scheduled.

To assess the dimensional gain obtained by the insertion of the grafts, it was decided to consider as indicative parameter the measure, expressed in millimeters, of the increase of the alveolar ridge of the posterior mandible in the lateral and / or vertical direction.

For some sites, when it was necessary only the increase of the horizontal ridge, it was found the average gain only in the lateral direction.

For other sites it was necessary to increase only the vertical dimension of the posterior atrophic mandibular ridge and it has been detected the vertical average gain.

In a lot of of sites it was necessary a dimensional increase both vertically and horizontally, and then the measurements were taken in both directions.

From the research performed on PubMed, 42 articles were obtained and analyzed, but only 10 of them corresponded to all the selection parameters.

In the 10 articles considered suitable, were identified 150 sites of posterior atrophic mandibles involved in graft interventions.

To each grafted site was attached a progressive number from 1 to 150 to identify it and to facilitate the comparison.

Below are specified the materials used in the various grafted sites. Are also reported the results of any association with protective membranes absorbable or not.

Considering the diversity of the techniques used it was not possible to do a statistical analysis (meta-analysis) of the results, but only the discussion.

## Results

The first survey carried out in the articles was the difference in the choice of graft materials.

It was found the use of autologous, homologous, heterologous materials and the combination of autologous and heterologous materials.

TABLE I.—*Summary of the grafts materials utilized.*

| Reference article | N° Sites | Type of graft material | | | | | |
|---|---|---|---|---|---|---|---|
| | | Single | | | Combination | Type and % membrane | |
| | | Autologous | Homologous | Heterologous | | | |
| (20) | 36 | 36 | 0 | 0 | 0 | 100 | (r) |
| (21) | 22 | 22 | 0 | 0 | 0 | 100 | (r) |
| (22) | 8 | 8 | 0 | 0 | 0 | 0 | - |
| (23) | 10 | 5 | 5 | 0 | 0 | 100 | (nr) |
| (24) | 7 | 7 | 0 | 0 | 0 | 0 | - |
| (25) | 30 | 6 | 24 | 0 | 0 | 0 | - |
| (26) | 9 | 0 | 0 | 9 | 0 | 100 | (r) |
| (27) | 4 | 0 | 0 | 0 | 4 | 100 | (r) |
| (28) | 14 | 0 | 0 | 0 | 14 | 100 | (r) |
| (29) | 10 | 2 | 0 | 0 | 8 | 100 | (nr) |
| Total | 150 | 86 | 29 | 9 | 26 | | |

Legenda: (r) resorbable membrane; (nr) non-resorbable membrane

The autologous materials used were of intraoral and extraoral origin.

The intraoral harvests were performed by the lateral oblique line in a total of fifty-eight sites [20,21]. The aim was to obtain an increase of the vertical and horizontal dimensions of the alveolar ridge of the posterior mandible. In these fifty-eight sites have been associated resorbable membranes to the grafts.

In 8 additional sites the intraoral autologous harvests were also carried out in the area of the symphysis or the ramus of the mandible, even in these sites was needed an increase in lateral and in vertical, but in these cases it was not associated with protective membrane for the graft.[22]

In 10 sites the autologous intraoral harvest from the retromolar area of the mandible has been used also in comparison with homologous material consisting of bone matrix DFDBA. In these 10 sites it was needed to obtain a vertical rise of the mandible and to both materials has been associated the use of a not resorbable e-PTFE protective membrane.[23]

In 7 sites the autologous bone was also harvested from extraoral locations as the iliac crest to obtain an increase in vertical ridge posterior mandible. In these cases to the graft was not associated any membrane.[24]

Autologous bone from the iliac crest has been used even in comparison with homologous material to obtain a vertical rise of the posterior mandible.

The allografts found in the analyzed sites were of two types: bone matrix containing DFDBA [23] and frozen bone obtained from the Bank of Tissues and Bone of the University Hospital A Coruña.[25]

The extraoral autologous harvest from iliac crest in 30 sites was compared with allogeneic frozen bone from the Bank of Tissues and Bone of the University Hospital A Coruña without the use of protective membrane.[25]

There are also 9 sites in which is inserted heterologous material of equine bone (blocks) and porcine bone (particles) with absorbable membrane.[26]

The graft materials have also been used in combination. In particular results 18 sites grafted with a combined use of inorganic bovine-derived bone (ABBM) with the autologous intraoral bone harvested from the retromolar area or from the retromolar area and the symphysis. In both cases it is necessary to obtain a lateral increase of the ridge and is also associated the use of a resorbable protective membrane.[27, 28]

In other 10 sites the combination of autologous intraoral bone of retromolar area has been associated with heterologous bovine-derived material (Bio-Oss) to obtain a

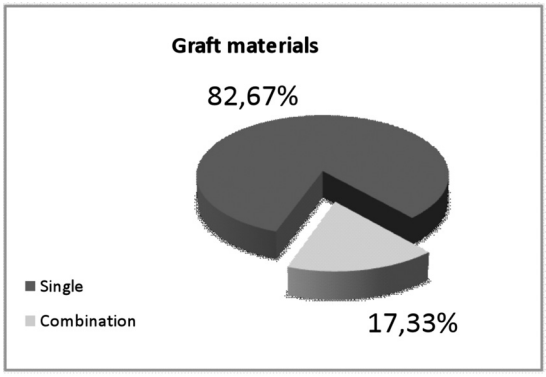


Figure 1.—Graft materials used single or in combination..

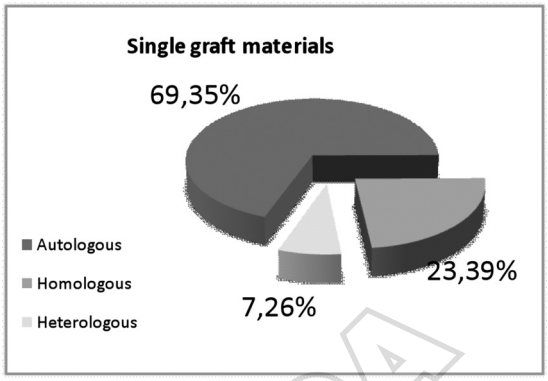


Figure 2.—Single graft materials used.

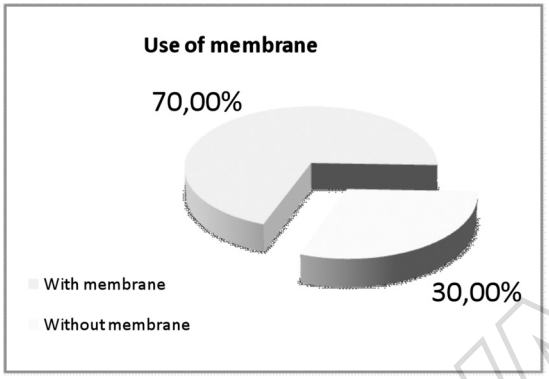


Figure 3.—Use of membrane.

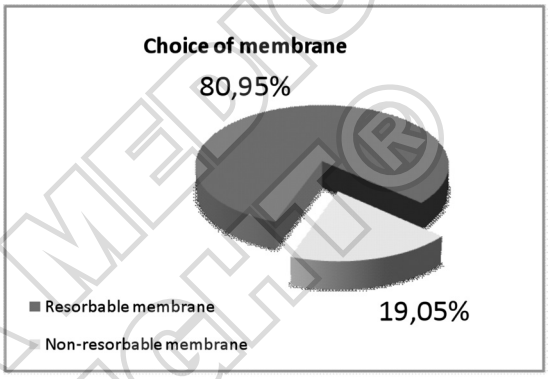


Figure 4.—Type of membrane used.

vertical augmentation of the mandible alveolar ridge, in these sites was also used a not resorbable membrane e-PTFE.[29]

The final result of the choices in the use of graft materials (Table I) noted that in 82,67% of cases was used a single graft material and 17,33% of the sites were used combinations of materials (Figure 1). Among the single

TABLE II.—*Survival rate of the grafts over time and complications.*

| Survival rate of the grafts | | | | |
|---|---|---|---|---|
| Reference article | N° sites | Success (%) | Time (months) | Complications |
| (20) | 36 | 100 | 17,55 | Transient sensory disturbances |
| (21) | 22 | 100 | 12 | Transient hypoaesthesia |
| (22) | 8 | 100 | 12 | - |
| (23) | 10 | 100 | 12 | Transient parasthesia |
| (24) | 7 | 100 | 14 – 16 | - |
| (25) | 30 | 100 | 12 – 93 | Permanent hypoaesthesia |
| (26) | 9 | 100 | 4 | Transient hypoaesthesia |
| (27) | 4 | 100 | 8,22 | - |
| (28) | 14 | 93 | 5,8 | Membrane exposure |
| (29) | 10 | 90 | 6 – 9,5 | Membrane exposure |
| TOTAL | 150 | 98,68 | | |
| AVERAGE TIME | | | 20,13 | |

TABLE III.—*Number of implants and survival rate of implants.*

| Survival rate of implants | | | |
|---|---|---|---|
| Reference article | N° implants | Survival (%) | Time (months) |
| (20) | 74 | 100 | 4 - 23 |
| (21) | 41 | 100 | 3 |
| (22) | 16 | 100 | 12 |
| (23) | 25 | 100 | 12 – 36 |
| (24) | 21 | 100 | 14 – 16 |
| (25) | 65 | 100 | 12 – 93 |
| (26) | 9 | 100 | — |
| (27) | 11 | 100 | 6,12 |
| (28) | — | — | — |
| (29) | 27 | 100 | 6 |
| Total | 289 | 100 | |

graft materials used in 69,35% of the cases it was autologous material, in 23,39% of cases allograft and in 7,26% of the sites heterologous material (Figure 2). It was also found that the membrane is used in 70% of cases, including 80,95% corresponds to resorbable membranes. (Figure 3, 4).

The grafts over time was survival in 98,68% of the sites, which were evaluated for a mean time of 20,13 months. (Table II).

Results that complications are related to sensory disturbance and exposure of the membrane. It also appears that it was possible to insert endosseous implants in the sites provided. (Table III).

Were also considered the results of the average gain in the lateral direction or vertical or in both directions, expressed in millimeters. In 21 sites there is the increase of the alveolar ridge of the mandible only in the lateral direction.[27, 28] (Figure 5).

In further 66 sites the increase of the alveolar ridge was only in the vertical direction[23, 24,25,26,29] (Figure 5).

There are also 63 sites that show the results with average gains both in the lateral and in the vertical direction [20, 21, 22] (Figure 5).

It should be noted that in an article 22 were reported 8 sites, but only 5 needed a gain in both directions. Specifically for the calculation of the vertical average gain, measurement refers to only 5 sites for which the value is known.

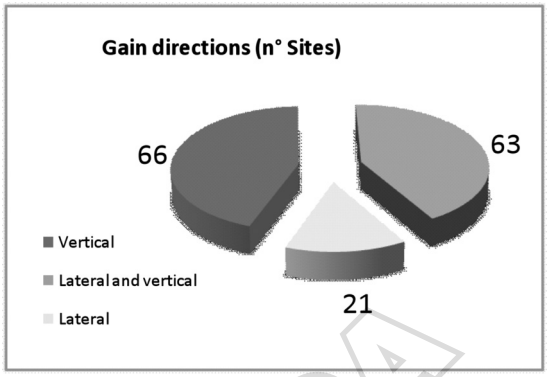


Figure 5.—Number of sites in wich is needed an increase in different directions.

TABLE IV.—*Grafts gain expressed in millimeters.*

| Grafts gain | | | |
|---|---|---|---|
| Reference article | N° Sites | Lateral gain (mm) | Vertical gain (mm) |
| (20) | 36 | 2.80 | 3.09 |
| (21) | 22 | 3.43 | 4.60 |
| (22) | 5 | 4.75 | 1.40 |
| | 3 | 4.75 | - |
| (23) | 10 | - | 4.40 |
| (24) | 7 | - | 6.67 |
| (25) | 30 | - | 5.30 |
| (26) | 9 | - | 7.47 |
| (27) | 4 | 6.50 | - |
| (28) | 14 | 4.60 | - |
| (29) | 10 | - | 3.18 |
| Average gain | | 3.63 | 4.40 |
| Standard deviation | | 0.98 | 1.44 |
| Range | | 3.70 | 6.07 |

It results that the lateral average gain is equal to 3,63 mm with a standard deviation of 0,98 mm in a range of 3,70 mm. The vertical average gain is 4,40 mm with a standard deviation of 1,44 mm in a range of 6,07 mm (Table IV). It turns out that in the sites with only lateral increase the average gain is 4,98 mm with a standard deviation of 1,54 mm in a range of 1,90 mm, and for sites with an increase only in the vertical direction the average gain is 5,28 mm with a standard deviation of 1,56 mm in a range of 4,29 mm (Table V).

Considering only the sites that needed a gain in both the directions, the average gain in lateral is 3,17 mm with a standard devia-

TABLE V.—*Average gain in different directions.*

| | Only Lateral | Only Vertical | Both directions | |
|---|---|---|---|---|
| | | | Lateral | Vertical |
| Average gain | 4.98 | 5.28 | 3.17 | 3.48 |
| Standard deviation | 1.54 | 1.56 | 0.71 | 1.31 |
| Range | 1.90 | 4.29 | 1.95 | 3.20 |

tion of 0,71 mm in a range of 1,95 mm and in vertical is 3,48 mm with a standard deviation of 1,31 mm in a range of 3,20 mm. (Table V) (Figure 6).

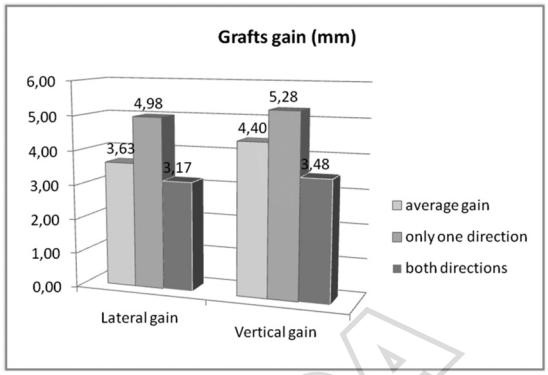


Figure 6.—Grafts gain in the different directions.

## Discussion

Considering the materials used it was observed that out of 150 sites covered by a graft has been used a single material in 124 sites, corresponding 82,67% of the total number of grafted sites. As regards the remaining 26 sites, equal to 17,33% of the total, has been used a combination of autologous bone and heterologous material of bovine origin. It can be deduced that in general has been preferred the use of a single material instead of combinations of materials.

Among the materials used individually in 86 sites (representing 69,35% of the sites that use a single material) it was preferred autologous bone graft, in 29 sites (representing 23,39% of the sites with a single material) was placed homologous material and in 9 sites (equal to 7,26% of the sites with single material) was used heterologous material. It can be observed therefore that the autologous bone graft material is the most widely used.

Autologous bone came from samples from intraoral regions of the mandible and from extraoral withdrawals from the iliac crest. Only in 13 of 86 sites was used autologous bone of extraoral origin.

It can be concluded that the material that is usefull used in the graft of atrophic posterior mandible is the autologous bone of intraoral origin taken from the mandible itself.

Still considering the materials used, it was found that of 150 sites analyzed in 70% of cases was also associated to the graft the use of a protective membrane, while only 30% of cases was not used any membrane.

It is also noted that in the sites where it was decided to insert a membrane in 95% of the cases was preferred an absorbable membrane, while only 19,05% of the cases a non-resorbable e-PTFE membrane. In summary, the analysis carried out showed that in graft interventions is preferred to associate a membrane and in particular a resorbable one respect to a non-resorbable membrane.

Considering the need to increase the size of the atrophic posterior mandible it was observed that in 150 sites the average gain side amounted to 3,63 mm while the vertical average gain reaches 4,40 mm.

Reprocessing the data may be observed that in 21 sites out of 150 total sites (equal to 14,00% of the sites) was required only an increase in the lateral direction, while 66 sites (representing 44,00% of total sites) was requires an increase only in the vertical direction and in the remaining 63 sites (equal to 42,00% of the total sites) was necessary an increase in both directions.

The sites that required an increase only in the lateral direction have obtained a lateral average gain equal to 4,98 mm, while sites requiring an increase in both directions have obtained a lateral average gain equal to 3,17 mm, then there is a lateral average gain greater when the increase takes place only in one direction.

The sites, where it was necessary only

the increase in the vertical direction, have obtained a vertical average gain equal to 5,28 mm, while the sites that require an increase in both directions obtained a vertical average gain equal to 3,48 mm. Also in the vertical direction there is a difference of average gain in the two cases and the highest increase is obtained when it is necessary to increase only in the vertical direction.

In summary therefore, by comparing the results, it can be deduced that, for both directions, can be obtained a greater average gain when it is increased the size of the atrophic posterior mandible in a single direction.

When necessary, it is anyway possible to obtain an increase of the atrophic ridge in both directions.

As with the increase in only one direction obtained a greater average gain, for sites that require an increase in both directions was considered the possibility of performing the necessary increase with two different operations, first in a direction and then in the other.

The literature analyzed have not revealed procedures of this type, probably because the patient's compliance would not be good because it increases the number of interventions necessary for the execution of the therapy.

It was noted however that the grafted autologous materials in atrophic posterior mandible are preferably taken from the mandible . This way of proceeding seems to make more acceptable insertion of the graft by the patient.

Considering the survival of the grafts over time in several cases there was a follow-up mean of 20,13 months with an overall survival rate of 98,68% in a total of 150 sites.

The survival rate so high may be linked to the fact that the grafts were followed for an average of time not high. In most of the found cases the average follow-up was greater than 12 months. However it is necessary to make studies evaluating the survival of the grafts for a greater length of time.

From what it could also be detected as complications there were 7 cases of transient hypoesthesia,[21, 26]7 case of transient paresthesia,[23, 25] 6 cases of transient sensory disturbances,[20] 2 exposures of the membrane [28, 29] and 1 case of permanent hypoesthesia.[25] This analysis shows that complications observed in the grafts are generally transient.

Comparing the survival rate of the grafts with the materials used can be seen that good results are obtained with all the materials used: autologous, homologous and heterologous.

In cases in which it was found a minor success the materials used are constituted by a combination of autologous bone taken from the mandible with intraoral heterologous bone of bovine origin, in a case of association with resorbable membrane and in one case with non-resorbable membrane.

In both situations occurred as a complication the membrane exposure.

The subsequent intervention of membrane removal has however led to the possibility of maintaining the graft and to obtain an increase in size of the atrophic mandible.

It can therefore be concluded that the surgical graft procedure in order to increase the volume of the edentulous posterior mandibular ridges leads to good results and complications in most cases are transient.

The graft procedure is aimed at the implant-prosthetic rehabilitation setting, it was examined whether the grafted sites was possible to insert endosseous implants.

From the results obtained it is clear that in the analyzed sites was possible to insert endosseous implants for implant-prosthetic rehabilitation fixed. In all studies, except one,[28] is also specified the number of endosseous implants inserted, and there was a total of 289 endosseous implants positioned with a good percentage of survival.

It should be noted that probably the percentage of survival of endosseous implants is high because, in the studies analyzed, the success is considered as the possibility to insert the implant and is not observed any bone loss around the endosseous implant over time.

## Conclusions

From the review carried out in the literature, although considering that there may be some complications generally transient, it is evident that the bone grafts lead to a gain both vertical and horizontal areas of the atrophic posterior mandible and therefore making it suitable to a fixed implant-prosthetic rehabilitation.

The autologous intraoral bone graft is the most analyzed and gets optimal results in increasing atrophic posterior mandible.

It is also important to consider that in the analyzed articles the follow-up is made not for long time.

It could be necessary in the future to make studies evaluating the survival of grafts for longer time.

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