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Review

Autogenous Tooth Graft Biomaterial in Guided Bone Regeneration: A Comprehensive Review

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Abstract: Objective: This review evaluated the use of autogenous tooth as a bone graft material in guided bone regeneration (GBR). Moreover, it compared the results of GBR using autogenous demineralized dentin, partially demineralized dentin, and mineralized dentin with or without membrane to verify its clinical advantage, effectiveness, and safety. Methods: A search was conducted in PubMed/MEDLINE, Lilacs, Embase, Cochrane, and Scopus databases. Specific criteria were established for the inclusion and exclusion of studies, including types of studies considered, target population (clinical studies: humans), evaluated intervention (studies assessing and comparing autologous demineralized dentin, partially demineralized dentin, and mineralized dentin in GBR with or without resorbable membrane), and language and publication period of articles (English and published in the last 11 years). A detailed assessment of the methodological quality of the selected studies was conducted using the JBI critical appraisal tool. Results: Based on the analysis conducted, out of 174 potentially relevant articles obtained, only 19 publications met the inclusion criteria, with three papers showing medium quality/moderate risk of bias and the rest with high quality/low risk of bias. Comparison between groups revealed stability of the newly formed bone, low marginal bone loss, clinically acceptable primary and secondary implant stability quotient (ISQ) values, and high implant survival rates after using autogenous tooth biomaterial. Conclusions: The results of this review on the use of autogenous teeth as a bone graft material in guided bone regeneration indicated that the technique has the potential to be an effective and safe treatment option. Analysis of selected studies showed favorable evidence for the use of autogenous teeth in bone regeneration, suggesting clinical benefits, most for socket preservation. These results are relevant for guiding clinical practice and assisting dental professionals in having options for biomaterials for bone regeneration.

Keywords: autogenous tooth; graft; bone regeneration; guided bone regeneration; dentin matrix; demineralized dentin matrix

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1. Introduction

The tooth extraction process triggers a series of morphological changes in the alveolar bone, resulting in bone remodeling that results in bone loss. This physiological condition can compromise the adequate three-dimensional (3D) placement of a dental implant [1,2]. Given this scenario, socket preservation techniques have been widely studied and recommended [1,3], with various biomaterials being employed, combined or not with membranes [4–7].

Demineralized dentin matrix (DDM), derived from the tooth, was first introduced in 1967 as a biomaterial. It has a similar chemical composition to the natural bone. DDM can be used as graft material for bone regeneration, such as in socket preservation, ridge augmentation, and sinus lifting procedures [8]. It is currently commercialized and has stood out mainly for its effectiveness associated with guided bone regeneration (GBR) procedures [9,10]. Its composition has inorganic components such as low-crystalline hydroxyapatite (HA), tricalcium phosphate (TCP), amorphous calcium phosphate (ACP), octacalcium phosphate (OCP), and organic components (non-collagenous proteins). It has demonstrated primarily osteoconductive activity, although some authors highlighted an osseoinductive potential [11,12]; in addition, it has low immunogenic capacity [13].

In 2015, for the first time, there was a chairside preparation of autogenous demineralized dentin graft (ADDG) through the tooth demineralization process. The results were promising, and it was considered a cheaper alternative biomaterial [9]. Dentin is rich in growth factors, which are essential for bone healing and regeneration processes, including transforming growth factor-beta (TGF-β), insulin-like growth factor-II (IGF-II), and bone morphogenetic protein-2 (BMP-2) [14]. A recent study [15] reported that the lack of enamel and periodontal ligament (keeping the dentin portion) for tooth preparation had the significantly highest rates for cell proliferation, presented increased gene expression (type I Collagen, RUNX-2, and BMP-2), and had a significantly greater formation of phosphate nodules; the authors reported that keeping the dentin part had promising osteogenic potential for use as a graft biomaterial.

However, the fact that dentin demineralization exposes its collagen matrix and releases growth factors is associated with challenges, such as prolonged preparation time, reduction in available graft volume, and extended exposure to acid, which can result in depletion of dentin and growth factors and a collapse of its 3D architecture [14]. Another recent alternative is the autogenous mineralized dentin matrix (MDM), which differs from ADDG by the absence of the demineralization process. These grafts, transformed into granulated mineralized dentin (particle granulometry from 250 μm to 1200 μm), represent a potential bone substitute in regenerative processes [16]. At present, autogenous demineralized dentin is available in two presentations: granules and blocks. Some researchers have pointed out that the shape and size of the granules have a significant impact on bone regeneration properties. Recently, in a comparative study involving different granule sizes and demineralization levels, Koga et al. [17] recommended the use of particles of around 1000 μm and partial demineralization with a solution containing 2% nitric acid. The development of innovative devices/equipment offers an automated alternative for the preparation of tooth graft materials, simplifying the process and ensuring the obtaining of quality bone grafts [18].

The aim of this review was to provide a comprehensive assessment of the effectiveness of using autogenous tooth material in GBR procedures in dental practice. This research was motivated by the absence of a systematic review that specifically investigated outcomes for this type of biomaterial in this specific technique. The results of this review can impact and guide clinicians and dentists to choose an alternative type of graft biomaterial for bone regeneration.

2. Materials and Methods

This comprehensive review followed the recommendations of the PRISMA guidelines to have a better organized and replicable methodology. The focus research question applied to this review was: "Does the use of autologous teeth in guided bone regeneration surgeries offer clinically significant advantages?" The PICO strategy was: Population (P): patients with a bone defect in the maxilla and mandible; Intervention (I): use of autologous tooth as bone replacement biomaterial in bone regeneration; Comparison (C): bone gain after surgery with or without the use of autologous tooth material; Outcome (O): efficacy/efficiency and clinical advantages/disadvantages.

2.1. Research Strategy

The search was carried out using PubMed/MEDLINE, Lilacs, Embase, Cochrane, and Scopus until 20 May 2024; a manual search was performed. The search strategy included the following keywords and MESH terms: "autogenous tooth", "bone graft", "bone regeneration", "tooth autotransplants", "tooth graft", "guided bone regeneration", "dentin", "dentin matrix", "demineralized dentin matrix". The following terms were joined by Boolean operators ("AND" and "OR"). Search terms were applied for the title and/or abstract analysis and were appropriately modified for each database. The data collected were organized in a table using Microsoft Excel (v.16 for Mac, Microsoft Office, San Francisco, CA, USA).

2.2. Eligibility Criteria

Only prospective, retrospective, cross-sectional, comparative, case series, randomized, and controlled clinical studies carried out in humans that evaluated and compared autologous demineralized and mineralized dentin in guided bone regeneration (GBR) procedures were included, considering the presence or absence of the resorbable membrane. Additionally, only articles written in the English language and published within the last 11 years (May 2013 to May 2024) were examined for this review. The exclusion criteria were applied to review articles, case reports, animal (in vivo) studies, in vitro studies, book chapters, editorial letters or letters to the editor, and studies older than 11 years that did not provide the necessary data/information for this research.

2.2.1. Screening and Selection of Studies

Two authors (A.P. and F.C.) independently evaluated all screening steps. Cohen's kappa test was performed. Articles identified using the search strategy were exported to Mendeley desktop Reference Manager software (v2.94) to check for duplicates. A first screening of titles and abstracts of records was carried out considering the inclusion and exclusion criteria. The remaining studies were assessed for eligibility and qualitative synthesis by full-text reading.

2.2.2. Study Data Collection

A bibliographic analysis was conducted, recording the authors, the year of publication, and the type of study. The examination methodology included the objectives, materials and methods, and results of the included studies, such as bone level before and after surgery, new bone formation, and the primary and secondary stability index (ISQ) of the implant, if available. Moreover, some additional variables were also collected, such as the control group, sample size, average age of the participants, inflammatory signs, complications, technical intervention, site of the implants, and number of implants placed, if available.

2.3. Risk of Bias/Quality Assessment

Risk of bias assessment was performed for each study using the JBI systematic reviews critical appraisal tool, which differs according to study type (cohort study, case–control study, case series, randomized controlled trial, and quasi-experimental study) between 9 to 12 questions; the possible answers could be: yes, no, unclear, not applicable. The final score for each study was obtained using the formula: (number of yes × 100)/(number of questions); JBI scores higher than 70% were classified as having a high quality, those with a score between 50% and 70% as having a medium quality, and those with a score less than 50% as having a low quality.

3. Results

A total of 174 studies were initially identified by electronic search (Figure 1). After excluding duplicated articles (n = 10), references marked as ineligible by automation tools (n = 48), and others removed for other reasons (n = 9; case reports and in vivo/in vitro studies), 107 articles were selected through the title evaluation; 56 articles were subjected to abstract reading. After screening, 27 articles were examined in full text. Three articles were excluded because they did not meet the inclusion criteria, and five articles were excluded because they did not provide the necessary data or the outcomes of interest were not measured. Hence, 19 studies [8,9,11–14,16,18–29] met the eligibility criteria and were included in this review to be qualitatively assessed (k = 0.90) (Figure 1). The selected studies and their main characteristics are summarized in Table 1.

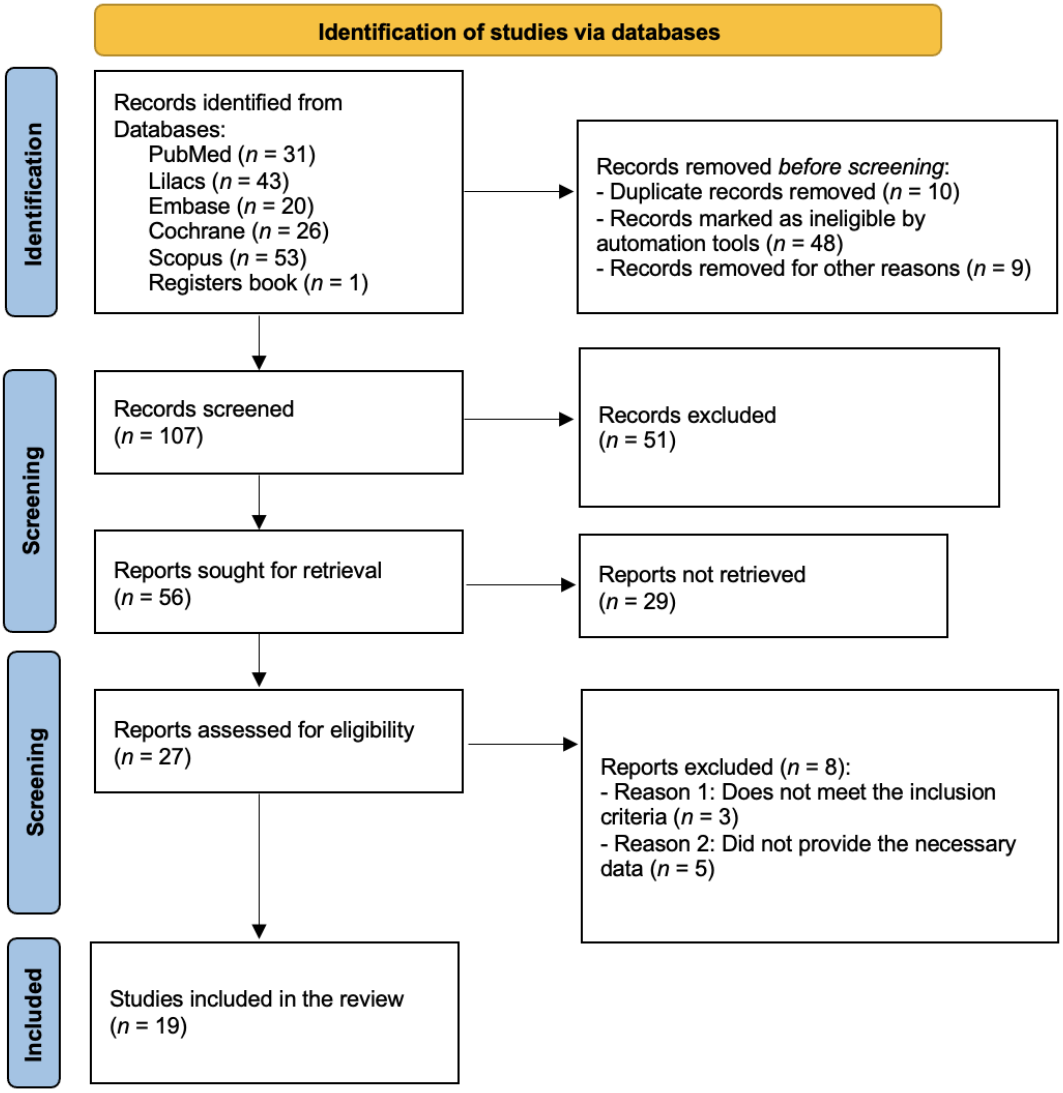

Figure 1. PRISMA flowchart for systematic reviews.

Table 1. Details of included studies.

	Author	Study Type	Sample (F/M)	Average Age—Years	Technique and Material Used	Site of the Implants	*n* of Dental Implants	Inflammatory Signs and Complications
1	Kim et al., 2016 [19]	Case series	3F/2M	41.6	Demineralized Auto-BT®; GBR; dental implants	1 mandibular implant 4 maxillary implants	5	No
2	Kim et al., 2013 [20]	Case series	4F/8M	NR	Demineralized Auto-BT® Block; GBR; implants; collagen membrane (5 patients) or without collagen membrane (7 patients)	19 maxilla 10 mandible	29	2
3	Kim et al., 2015 [9]	Case series	9F/29M	49.8	Auto-FDT®; GBR; implants; resorbable collagen membrane (29 patients) or a titanium mesh (9 patients) (CTi-memTM®, Neobiotech, Seoul, Korea)	32 maxilla 26 mandible	58	No
4	Minetti et al., 2023 [18]	Case series	8F/12M	57.33 ± 11.09	AutoBT®; GBR; resorbable osseoguard membrane (Zimmer [Warsaw, Indiana, USA]); implants	NR	20	No
5	Minetti et al., 2021 [21]	Case series	269F/235M	54.09	AutoBT®; GBR; dental implants; resorbable collagen membrane	278 maxilla 205 mandible	483	27
6	Kim et al., 2010 [22]	Case series	3F/3M	44.83	AutoBT®; GBR; dental implants	6 maxilla 1 mandible	7	No
7	Minetti et al., 2019 [23]	Case series	8F/7M	43	Auto-BT®; GBR (11 patients) or maxillary sinus elevation (4 patients); dental implants; resorbable porcine pericardial membrane® (BEGO Implant Systems GmbH & Co., KG, Bremen, Germany)	NR	12	1
8	Kim et al., 2014 [24]	Case series	7F/8M	49.9	Auto BT® block (1 patient) or particulate (14 patients); GBR; dental implants; resorbable collagen membrane (8 patients)	5 maxilla; 18 mandible	23	3
9	Lee et al., 2013 [25]	Case series	2F/7M	49.88 ± 12.98	Auto BT® block (2 Areas) or particulate (13 areas) or both (11 Areas); GBR; dental implants; titanium mesh or resorbable membrane (BioGide®; Osteohealth/Ossix; OraPharma, Warminster, PA, USA) or non-resorbable membrane (TR Goretex®; WL Gore & Associates, Flagstaff, AZ, USA)	24 maxilla 2 mandible	26	NR
10	Lee et al., 2013 [11]	Comparative analysis	Test group: 1F/8M; Control group: 4F/8M	Test group: 49.8 Control group: 57	Test group: With resorbable membrane (Bio-Arm®, ACE Surgical. Supply Company, Inc., West Columbia, SC, USA); Demineralized Auto-BT®; GBR; dental implants Control group: Without resorbable membrane; Demineralized Auto-BT®; GBR; dental implants	Test group: 3 maxilla 13 mandible Control group: 6 maxilla 8 mandible	NR	1 case for each group

11	Chang et al., 2014 [26]	Retrospective study	6F/4M	55.4	Demineralized Auto-BT®; GBR; implants; resorbable membrane (Bio-Gide®, Geistlich Pharma AG®, Wolhusen, Switzerland) and non-resorbable membrane (Gore-tex®, WL Gore & Associates®, Flagstaff, AZ, USA)	4 maxilla 7 mandible	11	No
12	Um et al., 2020 [27]	Pilot study	37F/59M	57.13	Test group (44 patients): Auto-DDM®; GBR; dental implants Control group (52 patients): Allo-DDM®; GBR; dental implants	54 maxilla 42 mandible	96	No
13	Li et al., 2018 [8]	Prospective clinical study	16F/24M	35.81	Test group (20 patients): Autologous DDM granules from the extracted tooth; GBR; immediate implants; BioGide membrane® (Osteohealth, Wolhusen, Switzerland) Control group (20 patients): Bio-Oss® granules (Geistlich Pharma AG, Wolhusen, Switzerland); GBR; immediate implants; BioGide membrane® (Osteohealth, Wolhusen, Switzerland)	Test group: 21 mandible Control group: 21 mandible	45	2
14	Sah and Baliga, 2022 [28]	Prospective study	8F/12M	27	Test group: AutoBT® with PRF membrane Control group: PRF membrane (PRF)	NR	NR	No
15	Pang et al., 2017 [29]	Prospective randomized clinical study	Test group: 11F/10M Control group: 6F/6M	Test group: 58.53 Control group: 60.56	Test group (21 patients): Auto-BT®; GBR; dental implants Control group (12 patients): Bio-Oss®; GBR; dental implants	NR	15	No
16	Yang et al., 2023 [12]	Randomized controlled clinical study	Test group: 9F/7M Control group: 6F/10M	Test group: 48.56 ± 13.46 Control group: 58.94 ± 16.09	Test group: Dentin matrix, partially demineralized autologous; GBR; implants; collagen sponge® (Wuxi BIOT Biologics Engineering Co., Ltd., Jiangsu, China) Control group: Spontaneous healing (SH)	Test group: 7 maxilla 9 mandible Control group: 4 maxilla 12 mandible	11 jaws; 21 mandibular	No
17	Elfana et al., 2021 [14]	Randomized controlled clinical study	Test group: 7F/3M Control group: 9F/1M	Test group: 33.5 ± 7.37 Control group: 31.2 ± 6.44	Test group: Autologous whole tooth; GBR; implants; bioabsorbable collagen membrane® (Hypro-Sorb®, Bioimplon GmbH, Munich, Germany) Control group: Demineralized dentin graft, autologous; GBR; implants; bioabsorbable collagen membrane® (Hypro-Sorb®, Bioimplon GmbH, Munich, Germany)	Test group: 7 maxilla 3 mandible Control group: 6 maxilla 4 mandible	Test group: 10 Control group:10	No
18	Santos et al., 2021 [16]	Randomized controlled study	Test group: 15F/11M Control	Test group: 56.8 ± 12.3 Control	Test group: Dentin matrix mineralized autologous; GBR; implants; absorbable barrier membrane (Bio-Gide®, Geistlich, Wolhusen, Switzerland)	NR	66	No

			group: 16F/10M	group: 61.5 ± 13.1	Control group: Granules of xenograft (Bio-Oss®, Geistlich, Switzerland); GBR; implants; resorbable barrier membrane (Bio-Gide®, Geistlich, Wolhusen, Switzerland)			
19	Li et al., 2023 [13]	Radiomics analysis	14F/11M	46	AutoBT®; Bio-Gide® collagen membranes; GBR; implants	First premolar (*n* = 3) Second premolar (*n* = 5) First molar (*n* = 14) Second molar (*n* = 14)	36	No

F = female; M = Male; NR = not reported; GBR = guided bone regeneration; PRF = platelet-rich fibrin.

Seventeen studies tested the partially demineralized dentin matrix and mineralized dentin matrix [16] in GBR surgeries. Thirteen studies used an absorbable or non-absorbable collagen membrane; two studies a titanium mesh [9,25]; a collagen sponge [12]; a platelet-rich fibrin (PRF) membrane [28]; and a porcine pericardial membrane [23]. Seventeen studies extracted teeth with immediate implant placement. Two studies compared demineralized dentin matrix granules with Bio-Oss® granules [8,29]; one study compared the entire autologous tooth with the demineralized dentin matrix [14]; another study compared the mineralized dentin matrix with xenograft granules [16]; two studies evaluated the demineralized dentin matrix block and particulate [11,24].

3.1. Quality Assessment of the Included Studies

A detailed assessment of the methodological quality of the studies is shown in Table 2. Three studies had a medium quality/moderate risk of bias. Neither study had a low quality/high risk of bias. Of the 19 studies included, 1 was a cohort study, 2 were case-control studies, 12 were case series, and 4 were RCTs.

Table 2. Study quality results according to the JBI assessment tool.

Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	% (Yes)	Risk Bias
Kim et al. [19]	N.A.	U	Yes	Yes	Yes	Yes	Yes	Yes	N.A.	No	No	No	60%	Medium quality/Moderate risk
Lee et al. [25]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	100%	High quality/Low risk
Chang et al. [26]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	100%	High quality/Low risk
Um et al. [27]	U	U	Yes	Yes	Yes	Yes	Yes	Yes	U	Yes	No	No	70%	Medium quality/Moderate risk
Kim et al. [10]	N.A.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	90%	High quality/Low risk
Li et al. [13]	U	Yes	Yes	U	U	Yes	Yes	Yes	Yes	N.A.	Yes	No	64%	Medium quality/Moderate risk
Yang et al. [12]	Yes	Yes	Yes	N.A.	N.A.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	83%	High quality/Low risk
Elfana et al. [14]	Yes	Yes	Yes	Yes	N.A.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	92%	High quality/Low risk
Santos et al. [16]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	High quality/Low risk
Kim et al. [9]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N.A.	Yes	No	No	90%	High quality/Low risk
Li et al. [8]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	100%	High quality/Low risk
Minetti et al. [18]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	U	No	No	90%	High quality/Low risk
Minetti et al. [21]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N.A.	No	No	90%	High quality/Low risk
Sah and Baliga [28]	U	Yes	Yes	Yes	Yes	Yes	Yes	Yes	U	Yes	No	No	80%	High quality/Low risk
Kim et al. [22]	N.A.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	U	No	No	80%	High quality/Low risk
Minetti et al. [23]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N.A.	No	No	90%	High quality/Low risk
Kim et al. [24]	N.A.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	U	No	No	80%	High quality/Low risk
Pang et al. [29]	Yes	Yes	Yes	N.A.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	92%	High quality/Low risk
Lee et al. [11]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	U	No	No	90%	High quality/Low risk

U = Unclear; N.A. = Not applicable.

3.2. Descriptive Summarization of the Included Studies

Tables 3–5 show the obtained clinical results. A description per article is provided to clarify the findings.

Table 3. Primary and secondary Implant Stability Quotient (ISQ).

Study	Author	Primary ISQ Average	*p*-Value	Secondary ISQ Average	*p*-Value
3	Kim et al. [9]	68	–	81	–
8	Kim et al. [24]	72	–	81	–
9	Lee et al. [25]	62	–	72	–
10	Lee et al. [11]	Test group: 63.64 ± 11.81 Control group: 65.53 ± 8.14	>0.05	Test group: 78.38 ± 6.85 Control group: 76.15 ± 7.08	>0.05
13	Li et al. [8]	53.6 ± 11.9	0.14	79.5 ± 6.0	0.09
15	Pang et al. [29]	72.80 ± 10.81	0.755	–	–
18	Santos et al. [16]	77.1 ± 6.9	0.807	81.8 ± 5.1	0.54

Table 4. Changes in marginal bone level (MBLevel) measured in mm before surgery (at time 0, T0) and after surgery (post-operative, PO); marginal bone loss (MBL) height measured in mm.

Study	Author	MBLevel T0 (mm): Average	*p*-Value	MBL PO (mm): Average	*p*-Value	Bone Height (mm)	*p*-Value
1	Kim et al. [19]	8.02	-	6.86	-	(−) from 0.2 to 3.25	-
5	Minetti et al. [21]	-	-	-	-	(−) 0.37 ± 0.68	>0.568
8	Kim et al. [24]	-	-	-	-	(−) 0.47	-
9	Lee et al. [25]	-	-	-	-	(−) 0.12 ± 0.19	-
10	Lee et al. [11]	Test group: 2.38 ± 0.28 Control group: 2.58 ± 0.34	>0.05	Test group: 2.19 ± 0.32 Control group: 2.35 ± 0.40	>0.05	Test group: (−) 0.19 ± 0.1 Control group: (−) 0.23 ± 0.11	>0.05
11	Chang et al. [26]	5.67	>0.05	5.99	>0.05	(+) 0.29	<0.01
12	Um et al. [27]	11.76 ± 1.84	<0.001	10.45 ± 1.77	<0.001	(−) 0.69 ± 0.81	0.141
13	Li et al. [8]	-	-	-	-	(−) 1.9 ± 0.6	0.18
15	Pang et al. [29]	12.04 ± 5.50	0.777	6.08 ± 5.53	0.887	−	-
16	Yang et al. [12]	7.24 ± 2.10	0.950	7.17 ± 1.56	0.005	(−) 0.07 ± 1.56	0.005
17	Elfana et al. [14]	8.95 ± 1.6	0.71	8.23 ± 0.27	0.31	(−) 0.72 ± 0.27	0.31
19	Li et al. [13]	6.63 ± 3.75	<0.001	9.82 ± 3.72	<0.001	(+) 3.19 ± 0.88	<0.001

Table 5. Assessment of new bone (NB) formation.

Study	Author	NB (%)	*p*-Value
4	Minetti et al. [18]	40.39 ± 15.86	-
5	Minetti et al. [21]	32.38 ± 17.15	-
6	Kim et al. [22]	46–87	-
10	Lee et al. [11]	Test group: 89.06 ± 27.33 Control group:	>0.05

		86.92 ± 22.78	
15	Pang et al. [29]	31.24 ± 13.87	0.606
16	Yang et al. [12]	39.67 ± 8.28	-
17	Elfana et al. [14]	48.4 ± 11.56	-
18	Santos et al. [16]	47.3 ± 14.8	<0.001

3.2.1. Case Series

1. Kim et al. (2016) [19]. This case series evaluated the long-term clinical results of using demineralized dentin matrix (AutoBT®) in five cases with GBR. Two surgeries were performed on each patient (n = 6); therefore, one of them did not complete the follow-up (moved out of country, with no complications at that point). The first surgery was GBR and immediate implant placement; the second surgery occurred between 2 and 6 months after (average of 4.6 months). The final prosthesis was delivered on average 4.8 months after the second surgery. Patients were followed for at least 5 years, with measurements of palatal height, buccal height, and alveolar ridge width to assess bone changes. Bone formation was compared between the second surgery and the final follow-up, focusing on marginal bone loss (MBL). A comparison of cone beam computed tomography (CBCT) images between immediately after primary surgery and 5 years later was performed to evaluate the formation and maintenance of corticocancellous bone and MBL.

The overall decreases in alveolar ridge width at the final follow-up ranged from 0 to 9.4% (0 to 0.9 mm). The changes in the bone area varied between the first and last follow-up visit (−25.7%, −29.9%, and −36.2%) in three cases, and −8.1% and −9.2% in the other two cases. At the final follow-up, four cases presented complete corticocancellous bone, while one patient still presented the bone formation process. Histological evaluation revealed that only one case showed no evidence of bone remodeling compared to the others. Furthermore, 1 mm of MBL was observed only in one case, on the buccal side.

2. Kim et al. (2013) [20]. This case series study aimed to evaluate the clinical and histological results of bone autologous tooth block graft (AutoBT® block) in conjunction with GBR. Dental implants (n = 29) were installed simultaneously or secondarily in 12 patients. AutoBT® block was used in different settings: either alone (six patients) or mixed with particulate bone graft material (six patients), and in conjunction with (five patients) or without (seven patients) collagen membrane. The results indicated that AutoBT® block proved to be useful in several surgical procedures (GBR, ridge augmentation, sinus augmentation, and after extraction). All cases showed positive success in bone graft results. After surgery, one patient developed wound dehiscence; however, favorable secondary healing was achieved. Osseointegration failure occurred in one of the implants. After a determined period, the bone was trephined for implant placement, showing histopathologically excellent bone healing owing to osteoconduction.

3. Kim et al. (2015) [9]. This study aimed to evaluate the clinical usefulness of the autologous bone graft from fresh demineralized teeth (Auto-FDT®), chairside prepared during dental implant surgery. The study included 38 patients who required tooth extraction and bone regeneration with implant placement. A total of 58 teeth were extracted and processed. In 29 patients, the graft biomaterials were covered with a collagen membrane, and a titanium mesh was used in nine cases. Eight patients received implants between 3 and 6 months after bone grafting. No significant complications were observed.

Twelve months after placing the implants, the wound healing, clinical results, and implant success rates were favorable, with minimal complications and adequate bone support for the implants. There was no implant loss after 12 months of function (100% survival rate), and the histological examination revealed new bone formation conducted by the graft material. Auto-FDT® graft was placed in blocks or particles, covered by an absorbable collagen membrane or titanium mesh. The average implant stability (ISQ) at the time of final prosthesis fabrication was 72.7 ± 5.2 (68–81), which was within the clinically acceptable range specified in Table 2. The histological examination showed bone growth around the Auto-FDT®, overlaying the graft with remodeling characteristics.

4. Minetti et al. (2023) [18]. This case series evaluated the effectiveness of a medical device capable of extracting dental graft biomaterials directly from a patient's tooth. Twenty patients requiring tooth extraction were included; the extracted tooth was used as graft biomaterial for socket preservation. All cases received a resorbable membrane that covered the graft. Immediate postoperative radiographs were performed for controls, and clinical examinations happened after 10 and 30 days to evaluate the healing process. After 4 months, the defects were significantly filled with newly formed bone. During dental implant placement, bone biopsies were trephined for histological assessment. The postoperative healing phase was free of infections or complications. Histomorphological analysis presented a total bone volume (BV) of 52.6 ± 13.09%, a new bone volume (NB) of 40.39 ± 15.86%, and a residual graft of 12.20 ± 12.34% (Table 4).

5. Minetti et al. (2021) [21]. This case series assessed the clinical results of the socket preservation procedure using Auto-BT® (autologous tooth biomaterial) in order to facilitate bone formation for posterior rehabilitation with dental implants. The study included 504 patients involving 13 dental clinics in different countries (multicentric study). After 4 months, 483 dental implants were placed. Bone biopsies were performed at the time of implant placement (after 4 months) for histological evaluation. After 12 months, only 27 postoperative complications were observed; the histomorphological analysis showed a high percentage of bone volume (BV) of 43.58% (±12.09) and new bone (NB) of 32.38% (±17.15), with no areas of inflammation or necrosis (Table 4). Only ten dental implants failed (2.3%), resulting in an overall implant survival rate of 98.2%; the peri-implant bone loss was 0.37 mm (±0.68) ($p > 0.568$) (Table 3).

6. Kim et al. (2010) [22]. This study evaluated the effectiveness of AutoBT®. Histomorphological analysis of samples collected from six patients over a healing period of 3–6 months revealed new bone formation (between 46% and 87% of the region of interest [ROI]), indicating excellent bone remodeling (Table 4). Over time, AutoBT® was gradually resorbed, whereas new bone increased (after 6 months).

7. Minetti et al. (2019) [23]. This case series tested a medical device to obtain dental grafts from patients' complete teeth. It included 15 healthy patients in good general health who were non-smokers; among them, there were 11 cases of GBR and four sinus elevations, all of them covered by a resorbable pericardial membrane. After 6 months, all defects were almost completely filled with newly formed bone with similar density (medium-density bone); no signs of inflammation or postoperative infectious complications were observed.

Initially, the mesiodistal defect was on average 10.83 mm, buccolingual 9.45 mm, and height 8.90 mm; after 6 months, it was on average 10.79 mm, buccolingual 10.17 mm, and height 8.70 mm. After 6 months, 19 titanium implants were placed, which resulted in high primary stability. After 12 months, 18 implants achieved complete osseointegration, and one failed in the second phase of surgery.

8. Kim et al. (2014) [24]. This case series evaluated the effectiveness of AutoBT® in GBR procedures treating 15 patients (two had simultaneous sinus lifting). Implants (n = 23) were placed in the upper and lower molars; eight patients received resorbable collagen membranes. Autologous graft biomaterials were employed (block in one patient and particles in the others).

The average ISQ of the implants was 72 (primary stability) and 81 (secondary stability) (Table 2). Regarding post-surgical complications, three cases had wound dehiscence; of these, two achieved favorable secondary healing and had almost no MBL, whereas two implants in one case had MBL of 3.6 mm and 2.5 mm. One patient developed a postsurgical hematoma. The average MBL was 0.47 mm (Table 3). The average follow-up was 31 months, with all implants in normal function. Excellent healing for the GBR was observed clinically, radiographically, and histologically. Tissue samples of 2 to 4 months of healing showed adequate bone healing, with newly formed bone and vascularized tissue.

9. Lee et al. (2013) [25]. This study assessed the results of vertical and horizontal crest augmentation with autologous tooth biomaterial (AutoBT®—blocks, particles, or both).

All implants were placed using a two-stage procedure; the second surgical phase was performed between 2 and 8 months after the bone regeneration. The assessment of bone resorption was carried out with periapical radiographs taken during a follow-up carried out one year after the placement of the definitive prosthetic rehabilitation.

Teeth (n = 29) from nine patients were used in the production of the AutoBT® material; AutoBT block® and particulate material were used in 11 areas, only particulate was used in 13 areas, and only the block in two areas. Resorbable or non-resorbable membranes were used in all cases except one that received titanium mesh. Implants (n = 26) were placed in the regenerated area.

The primary ISQ of the implants, determined using OssTell®, was 62 (52–86), while the secondary ISQ was 72 (63–85) (Table 2). The postoperative evaluation revealed one case of wound dehiscence and hematoma. All cases had successful results. MBL after one year was stable at 0.12 ± 0.19 mm (Table 3). One case rehabilitated in the region of the first lower right molar with vertical crest augmentation showed mobility in the dental implant after 9 months, and it was removed (implant survival rate was 96%).

3.2.2. Comparative Analysis

10. Lee et al. (2013) [11]. This study analyzed the clinical results of GBR using autologous tooth biomaterial with and without resorbable membrane (Bio-Arm®, ACE Surgical Supply Company, Inc., West Columbia, SC, U.S.A.). The study included 20 patients with a total of 30 dental implants: eight patients (16 implants [three in the maxilla and 13 in the mandible]) in the test group (with resorbable membrane) and 12 patients (14 implants [six in the maxilla and eight in the mandible]) in the control group (without membrane). The average value of bone level changes was 2.19 ± 0.32 mm in the test group, while it was 2.35 ± 0.40 mm in the control group ($p > 0.05$) (Table 3).

The average primary stability values were 63.64 ± 11.81 ISQ in the test group and 65.53 ± 8.14 ISQ in the control group. The average secondary stability values were 78.38 ± 6.85 ISQ in the test group and 76.15 ± 7.08 ISQ in the control group ($p > 0.05$) (Table 2). Bone gain was 89.06% in the test group and 86.92% in the control group ($p > 0.05$) (Table 4). The test group had 81% of the implants with complete bone regeneration, whereas the control group had 64%. Each group presented one case with postoperative complications.

3.2.3. Retrospective Study

11. Chang et al. (2014) [26]. This study evaluated, through radiographies, MBL after functional loading of the implants that were placed into GBR-treated sites; the graft used was autologous tooth-based bone graft (ATBBG) biomaterial. Of 19 patients initially enrolled, 12 returned for follow-up. GBR was performed with ATBBG in 10 of these patients. Resorbable membranes (Bio-Gide®, Geistlich Pharma AG, Wolhusen, Switzerland) were used in eight patients, non-resorbable membrane (Gore-tex®, WL Gore & Associates, Flagstaff, AZ, USA) was used in one patient, and both types of membranes were used in another patient. Panoramic and periapical radiographs were taken at each stage of treatment.

No significant differences in MBLs were observed immediately after GBR, implant placement, and prosthesis delivery ($p > 0.05$) (Table 3). A statistically significant correlation was observed between the marginal bone height after GBR and after implant placement, indicating that the height after GBR did not change substantially even after implant placement ($p < 0.01$) (Table 3). Between genders, there was a statistical significance in MBL after prosthesis delivery compared to that after GBR and implant placement. The average differences between treatment phases for male and female patients were: (1) after GBR—male: −0.74 mm, female: 1.02 mm ($p < 0.05$); (2) after implant placement—male: −1.63 mm, female: −0.01 mm ($p < 0.05$); (3) after delivery of prostheses—male: 0.03 mm, female: −0.06 mm ($p < 0.05$). There were no complications during the total observation period.

3.2.4. Pilot Study

12. Um et al. (2020) [27]. The authors evaluated the resorption rate of autogenous (Auto-DDM) and allogeneic demineralized dentin (Allo-DDM) used for GBR around dental implants. Between 2014 and 2019, 96 patients were included, of whom 52 were treated with Allo-DDM® and 44 with Auto-DDM®. The buccal cone height was measured immediately after GBR (T1 = 11.76 ± 1.84 mm), after prosthetic loading (T2 = 11.09 ± 1.70 mm), and after 12 months of functional loading (T3 = 10. 45 ± 1.77 mm) (Table 3). They showed a significant decrease for each period ($p < 0.001$); both resorption ($p = 0.973$) and functional resorption ($p = 0.141$) were not statistically significant comparing Auto- and Allo-DDM. The initial resorption in the maxilla (0.82 ± 1.18 mm) was greater than in the mandible (0.59 ± 0.54 mm) ($p = 0.145$). The functional resorption was similar between the maxilla and mandible (0.71 ± 0.90 and 0.67 ± 0.67 mm, $p > 0.05$). There were no complications during the total period.

3.2.5. Prospective Clinical Studies and Randomized Controlled Trials

13. Li et al. (2018) [8]. This prospective clinical trial aimed to evaluate the clinical efficacy of autologous DDM granules compared to Bio-Oss granules® (BIO) in GBR, for immediate implant placement. The trial included 40 patients with a total of 45 implants, divided into the DDM and BIO groups. Implant stability was assessed immediately after the procedure (53.6 ± 11.9) ($p = 0.14$), at 6 months (77.6 ± 7.9) ($p = 0.11$), and after 18 months (79.5 ± 6.0) ($p = 0.09$) (Table 2). Similarly, MBL was assessed immediately, after 6 months (1.7 ± 0.3 mm) ($p = 0.25$), and after 18 months (1.9 ± 0.6 mm) ($p = 0.18$) (Table 3). Only two cases (one in the DDM group and one in the BIO group) presented with wound infection (success rate of 95.6%). The ISQ values of these two implants were excluded from the statistical calculations.

After 1 year of prosthetic loading, 43 implants showed no postoperative complications, achieving a satisfactory result. No statistically significant differences were found between the DDM and BIO groups in terms of implant stability and MBL in all periods ($p > 0.05$). The radiographic density between the newly formed bone and the alveolar bone did not show statistically significant differences in most cases.

14. Sah et al. (2022) [28]. In this prospective study, the authors intended to evaluate the effectiveness of autologous tooth grafts in the fresh sockets (immediately after extraction) in the third molar region. Twenty patients who required bilateral extractions were included in the study. Patients were divided into two groups: Group A (control group) used platelet-rich fibrin (PRF) membrane to fill the socket, followed by closure of the site by primary intention; and Group B (test group) used tooth graft covered by PRF membranes and primary intention closure. Bone healing was assessed (cortical aspect, density, and trabecular pattern) through radiographs at 7 days, 1 month, 3 months, and 6 months. Group B showed significantly faster bone healing than Group A in terms of density and trabecular pattern at 3 and 6 months. No statistical significance was found regarding the cortical aspect, and the density score was significantly higher in Group B in all time intervals. There was a statistically significant difference in the trabecular pattern scores of Group B compared to Group A. No postoperative complications were recorded after 3 and 6 months.

15. Pang et al. (2017) [29]. The authors aimed to evaluate the clinical efficacy and histological results of autologous dental graft biomaterial (AutoBT®) compared to inorganic bovine bone graft (Bio-Oss®) in post-extraction alveoli. The study included 33 graft sites in 24 healthy patients, with AutoBT® used at 21 sites and Bio-Oss® at 12 sites. No complications or infections were observed in both groups.

There was no statistically significant difference in the vertical dimension between both groups. After 6 months, the average defect heights were 6.08 ± 5.53 mm in the AutoBT group and 6.11 ± 4.16 mm in the Bio-Oss group ($p = 0.887$) (Table 3). There was no statistically significant difference between both groups ($p = 0.337$) for bone gain. The implant

stability quotient (ISQ) was comparable between groups (72.80 ± 10.81 for AutoBT and 70.0 ± 12.86 for Bio-Oss; $p = 0.755$) (Table 2). The histomorphological analysis indicated that new bone formation also showed no significant difference ($p = 0.606$) (Table 4). Similarly, the average percent of residual graft material, though higher in the bovine bone graft, showed no significant difference ($p = 0.245$).

16. Yang et al. (2023) [12]. The authors assessed the effectiveness of autologous partially demineralized dentin matrix (APDDM) in socket preservation. Using radiography and histomorphology, the study compared spontaneous healing (SH) in severely periodontally compromised alveoli. Patients ($n = 32$) enrolled in the study were divided between the test group (APDDM) with 16 patients and the control group with the other 16 patients, who underwent SH. No statistical differences were observed between groups for height and width of residual socket dimensions at baseline ($p > 0.05$).

Through cone beam computed tomography (CBCT) and histomorphometrical analysis, the sites were measured before extraction and again after 4 months of healing. The results showed that the test group had a greater increase in ridge width and bone height compared to the SH group. Moreover, the bone volume also increased significantly in the test group (increase in 387.55 ± 399.85 mm^3, 37.07%, $p < 0.05$). The histomorphometrical results revealed the formation of new bone surrounding the APDDM particles, osteoconduction, with an average of 39.67% (Table 3). Additionally, no significant outcomes in thickness as well asor in the MBL were observed. All cases presented uneventful postoperative healing, and no complications were recorded anywhere.

After 4 months, significant differences between groups were identified in the horizontal width at 1 mm apical to the crest (HW1) and 3 mm apical to the crest (HW3) ($p < 0.05$). The mesial bone width, mid-face, and distal crest, at 1 mm apical toward the crest, increased by 5.03 mm, 4.50 mm, and 5.20 mm, respectively, in the APDDM group, while it decreased by 1.98 mm, 2.19 mm, and 1.98 mm, respectively, in the SH group ($p < 0.05$). No significant differences between groups were found in ridge width at 5 mm apical to the ridge ($p > 0.05$).

Regarding height changes, significant differences were observed between the APDDM and SH groups at mesial, mid-face, and distal sites, as well as at the heights of the central bone plate. Specifically, the APDDM group showed an increase of 0.37 and 7.28 mm in the mesial area and central bone, respectively, while the SH group exhibited a decrease of 2.33 mm and an increase of 3.31 mm in the same respective areas ($p < 0.05$). However, no significant changes in the height of the lingual/palatal bone plate were found in the three spots.

17. Elfana et al. (2021) [14]. This RCT evaluated the radiographic changes and histological healing after socket preservation with autologous whole-teeth graft (AWTG) in comparison with autologous demineralized dentin graft (ADDG). Non-molar teeth ($n = 20$) were equally and randomly divided into two groups and prepared as AWTG or ADDG, and then covered with collagen membrane. After 6 months, CBCT and bone biopsies were performed. The results showed that both groups presented normal healing without complications, with crestal width and height reduction. Histologically, there was no inflammatory reaction, and both samples showed new bone formation. Table 3 presents the dimensions obtained for the groups. After six months, no differences were found for the dimensions between groups ($p > 0.05$). In the histomorphometrical quantification, the AWTG group had a total bone area of 37.55 ± 8.94%, whereas the ADDG group achieved 48.4 ± 11.56% (Table 4).

18. Santos et al. (2021) [16]. This RCT assessed the primary stability of late implants in sites preserved with autologous mineralized dentin matrix (MDM) versus xenograft biomaterial. Patients ($n = 52$) were randomly assigned to the groups before socket preservation. Overall, age, gender distribution, and smoking habits were similar between groups ($p > 0.05$). There were no postoperative complications (infection or wound dehiscence). The primary stability of the implant was measured immediately and 2 months after implant placement (Table 2), with no significant results found ($p > 0.05$). The MDM

group presented a significantly higher percentage of newly formed bone (47.3%) than the control group (34.9%) ($p < 0.001$) (Table 4).

19. Li et al. (2023) [13]. This study evaluated AutoBT® (Auto Bone Transplantation) in stimulating bone growth during socket preservation, in cases of severe periodontitis. Twenty-five cases were enrolled. AutoBTs® were inserted and covered with Bio-Gide® (collagen membrane). CBCT and 2D radiographs were performed before and 6 months after surgery for assessment. All wounds healed within the first 6 months, and all 36 surgical sites were free of complications. In the maxilla, alveolar height decreased by 2.15 ± 2.90 mm at the buccal crest, 2.45 ± 2.36 mm in the center of the cavity, and 1.62 ± 3.19 mm in the palatal crest ($p < 0.05$); whereas in the mandible, the height of the buccal crest decreased by 0.19 ± 3.52 mm, the height at the center of the cavity had a reduction of 0.70 ± 2.71 mm, and at the lingual crest increased by 5.07 ± 4.34 mm ($p < 0.05$). Three-dimensional images demonstrated general significant bone growth in local alveolar height and high density. The average baseline bone height in the experimental group was 6.63 ± 3.75 mm and the final bone height was 9.82 ± 3.72 mm, 6 months after surgery. There were significant differences between pre- and postoperative alveolar dimensions ($p < 0.001$).

4. Discussion

Observing the "gap" in the literature for the use of tooth graft biomaterials in GBR procedures, the goal of this study was to provide a comprehensive assessment of the effectiveness of using autogenous teeth in GBR procedures. The GBR technique has been largely applied in daily clinical practice to recover/reconstruct bone deficiencies or keep dimensions such as in cases of extraction. The use of membranes provides a good cellular barrier (osteopromotion), helps stabilize blood clots, and facilitates the attachment of bone cells to them, thus increasing osteogenesis. In the case of socket preservation, it is possible to preserve the bone volume better, ensuring adequate bone availability for future implant placement [13].

Many studies have supported using autogenous, homologous, synthetic, or xenogeneic bone grafts for socket preservation, bone reconstruction, and rehabilitation. While autogenous biomaterial is the gold standard for bone reconstruction, alternative treatments have presented a high success level. The use of tooth as a graft biomaterial, under a scientific and controlled process, can be considered relatively new. It is an autogenous material and has already been commercialized.

4.1. Evaluating Tooth Biomaterial Performance

AutoBT®, a commercial tooth biomaterial, has demonstrated efficacy associated with GBR in the short term, successfully maintaining corticocancellous bone after functional loading [19]. In the case series conducted by Lee et al. [25] and Kim et al. [24], excellent healing was achieved using AutoBT®, which was evidenced by clinical, radiological, and histological evaluations. The bone level around the implants remained stable in most patients; however, in two cases [24], a more significant loss was observed, but the bone healing was satisfactory. Similar results were found by Minetti et al. [18]. Moreover, the osteoconductive property was observed after reviewing the histological repair from the areas grafted with AutoBT® blocks [20]. Li et al. [13] reported that, after 6 months, a histological evaluation of AutoBT® showed favorable bone healing, confirming osteoconduction processes.

Recent studies have suggested that AutoBT® offers comparable or even better results than other bone substitutes, but there is insufficient evidence on its long-term outcomes, specifically after 5 years. The findings presented in the results of this review suggest that AutoBT® is effective in promoting bone regeneration and maintaining peri-implant bone stability over time, highlighting its potential as a viable therapeutic option in GBR procedures [24]. Similar results were obtained when evaluating MBLevel after ATBBG grafting [26].

4.2. Comparing Tooth Graft with Other Biomaterials or Blood Clots (Negative Control)

The comparison of Auto-DDM® with Bio-Oss® granules in GBR for cases after immediate implant placement presented an implant success rate of 95.6% in the first year for both groups [8]; similar results were found comparing Auto-BT® and Bio-Oss® [29]. In an environment of severe periodontal destruction [12], APDDM was used for socket preservation compared to spontaneous healing (SH; blood clot). The biomaterial used was more effective in preserving or reconstructing the alveolar crest dimension (horizontally and vertically) than SH. Similar results were obtained by Minetti et al. [18], with an overall implant survival rate of 98.2% for the implants placed in the sites treated.

Effective socket preservation was found when comparing autologous whole tooth and autogenous demineralized dentin; however, autogenous demineralized dentin graft had better remodeling, integration, and osteoinductive properties [14]. In addition to the type of dentin matrix used, the degree of demineralization also plays an essential role in its osteogenic effect; partially demineralized dentin matrix has been shown to have superior bone regeneration compared to non-demineralized or completely demineralized dentin matrix [12].

Similar results were reported comparing the primary stability of dental implants on sites preserved with MDM® (autogenous mineralized dentin matrix) with xenograft granules [16]. The results obtained with MDM® can be attributed to the similarity in composition between dentin and human bone and the bone induction potential demonstrated by decalcified dentin [9]. In summary, MDM® is a viable and option comparable to xenograft for socket preservation, as observed in other investigations [9,29].

4.3. Maxilla versus Mandible

Comparing the arches, it was noted that the buccal bone height in the maxilla showed higher resorption than in the mandible during the initial and functional periods [30]. On the other hand, Száva et al. [31] reported that implants placed in the upper arch had less bone loss than in the mandible after 1 year of loading. This shows that there are differences between the maxilla and mandible in the remodeling processes after GBR, with the possibility of greater volumetric shrinkage in the maxilla than in the mandibular [12].

Mahesh et al. [32] reported a high implant success rate of 98.1% with three cases of implant failure (98% for the maxilla and 99% for the mandible); two of them were maxillary implants that failed before implant loading, with no particular reason, and another failure was detected 4 years after loading, with possible justification for the excessive loading on the single implant. A prospective study [33] reported survival rates for immediate implants as high as 92.4% in the maxilla and 94.7% in the mandible. Another study reported a similar conclusion [34]. Therefore, although the mandibular implants had a better survival rate than maxillary implants, there was no statistically significant difference [35,36].

4.4. Membranes and Clinical Complication

The use of membranes may increase the frequency of surgical wound exposure. Early membrane exposure can result in a reduced amount of regenerated peri-implant tissue, compromising bone regeneration around the implants by up to 80% [11]. In a study by Lee et al. [11], one case had dehiscence with wound opening, resulting in membrane exposure (resorbable collagen membrane group). After conservative care, no other infection related to exposure was reported. The study also showed that 81% of cases in the resorbable collagen membrane group had complete bone regeneration, compared to 64% in the non-membrane group. No statistically significant differences were found between the two groups regarding pre- and postoperative reduction in bone defect height, change in bone level, and percentage bone gain. Kadkhodazadeh et al. reported that collagen matrix is a good option to treat and manage small gaps (3–4 mm), with promising outcomes [37].

The association of a membrane with AutoBT® showed that a resorbable membrane was not a critical factor in GBR when associated with AutoBT® [25]. Similarly, regardless of the use of membranes, a non-significant result was found comparing groups with and without membranes, despite a percentage increase in bone formation being observed [38], similar to observations of another recent study [39]. This fact can be justified by the shape of the defect or the qualities of the graft materials, which were more crucial factors than the characteristics of the membrane itself. However, other factors, such as an adequate healing period, healthy periosteum, and good oral hygiene, played essential roles in bone formation after GBR.

4.5. Limitations of the Study

This study had limitations, such as the inclusion of articles that only performed GBR; inclusion of only clinical evaluations (humans), which limited the histological analysis, e.g., of in vivo studies; and high heterogeneity observed among the studies, which did not permit any deep data analysis.

5. Conclusions

The findings of this review affirm that autogenous demineralized dentin matrix is a promising and effective alternative in GBR, mainly for alveolar ridge augmentation and socket preservation, providing favorable clinical results and correlated to a high implant survival rate. The process for obtention of the matrix can be considered controlled and simple. In this sense, it is important to emphasize the development of clinical protocols, allowing future clinical studies with better standardization, larger samples, and longer follow-up times. These would allow researchers to obtain more reliable and precise responses for evaluating advantages and disadvantages in order to provide the highest-level information to clinicians.

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