

# AUTOGENOUS DENTIN AS A BONE SUBSTITUTE: A REVIEW

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## Abstract

**Aim:** Regeneration of bone defects is a major problem that continues to inspire the design of new bone materials. Autogenous bone, with its osteogenic, osteoinductive and osteoconductive properties, has long been considered the ideal grafting material in bone reconstructive surgery although due to its limitations, various bone substitutes has been introduced. The aim of this literature review was to evaluate autogenous dentin as a bone substitute.

**Method:** Electronic Search was conducted in a direct scientific article, Google Scholar, update, Wiley online library, PubMed with keywords for autogenous dentin, bone grafts, growth factors, Autogenous tooth, Allografts, Alloplastic bone, Xenografts between 2010 and 2017, and selected articles that are more relevant to the subject.

**Result:** Healing of autogenous bone grafts entails both osteoconduction, where new bone is gradually formed around the resorbing graft, and osteoinduction, where released proteins are capable of stimulating osteoblasts or pre-osteoblasts to form new bone. Allografts have been found to possess bone-stimulating proteins and, consequently, osteoinductive properties.

**Conclusion:** Autogenous dentin can be used as an appropriate bone substitute. The present results indicate that the treated autogenous dentin graft could be used as a bone substitute for enhancing bone regeneration.

**Key words:** *Autogenous Dentin, Bone Substitute, Bone Grafts.*

## Introduction

Bone grafting techniques have been used by clinicians for more than 100 years.<sup>1</sup> There are many applications for using bone and bone substitutes in medicine, including restoring form and function to the skeletal structure, providing stabilization, and enabling aesthetic modifications. In dentistry, allogeneic bone and synthetic mineral materials are the main sources for grating in bone. However, fresh autogenous bone graft is still considered gold standard since it exhibits bioactive cell instructive matrix properties and is non-immunogenic and non-pathogenic in spite of the need for harvesting bone and possible morbidity resulting from it.<sup>2</sup> Autogenous bone, with its osteogenic, osteoinductive and osteoconductive properties, has long been considered the ideal grafting material in bone reconstructive surgery. However, drawbacks with autogenous bone include morbidity, availability and unpredictable graft resorption. On the other hand, Allografts and Xenografts may cause immunologic, infectious, and inappropriate fibrosis repair. The construction of collagen scaffolds is engineered from natural materials. One of these materials is Dentin, which has been introduced as an ideal alternative to bone. Different methods have been proposed for dental transplants and dentin transplantation to a bone defects such as using a dentin block and fixing with fixation screws and using dentin particles or dentin sheet.<sup>3</sup>

## Method

Electronic Search was conducted in a direct scientific article, Google Scholar, update, Wiley online library, PubMed with keywords for autogenous dentin, bone grafts, growth factors, Autogenous tooth, Allografts, Alloplastic

bone, Xenografts between 2009 and 2017, and selected articles that are more relevant to the subject.

## Result

### *Bone grafts and growth factors*

Autogenous grafts and allografts were among the first types of bone graft used and are still widely used today. Autogenous bone graft is considered the benchmark because it possesses all the properties required while retaining complete histocompatibility. It is osteoconductive, osteoinductive (owing to the presence of growth factors), and contains living osteogenic cells. Some forms of autogenous graft (for instance vascularised fibula grafts) can also provide structural support. However, autogenous grafts are in limited supply and are associated with high rates of donor site morbidity, which may lead to an increased inpatient stay and higher associated costs. The major and minor complication rates of autogenous bone graft harvest have been reported at 8.6% and 20.6%, respectively.<sup>4</sup> The most commonly used bone grafts are the autogenic, for besides being immunologically compatible, they are also those which present the best results related to the stimulus of the bone regeneration.<sup>5</sup> Histological examination of the grafted revealed the formation of a dentin-bone complex, where tooth-bone graft was surrounded by newly forming bone. The amount of time required for resorption of the graft varied considerably, and the histologic studies showed a characteristic picture of graft particles encased in newly formed bone. The tooth-bone grafted sites demonstrate a dentin-graft complex with high variability in terms of resorption and remodelling time ranging from 2 weeks to 6 months and more. Tooth bone graft showed an increased risk of dehiscence, particularly in

block grafted sites ranging from 12.96% to 34.38%. Also, high risk of bias was noted for 38 (21.11%) animal study entries and 1 (25%) human randomized controlled trials, whereas an unclear risk of bias was noted for 28 (15.56%) animal study entries and 1 (25%) human randomized controlled trial.<sup>6</sup> The rigidly fixed autogenous tooth graft achieves progressive ankylosis with bone. Moreover, the interface between the tooth and bone was kept stable and intact during the process of bone remodelling. Thus, the rigid fixation may be used to stabilize the graft and provides a good clinical outcome. On the other hand, ankylosis of both dentin and enamel further showed the good biocompatibility of autogenous tooth as bone substitute material. The process of bone remodelling involved slow ankylosis between the bone and grafted tooth in the form of vascularization, resorption of grafted tooth, and formation of new bone.<sup>7</sup> Healing of autogenous bone grafts entails both osteoconduction, where new bone is gradually formed around the resorbing graft, and osteoinduction, where released proteins are capable of stimulating osteoblasts or pre-osteoblasts to form new bone. In many aspects, the healing of bone grafts is similar to the healing of fractures.

#### *Allografts*

Autografts are harvested and transferred from intraoral or extraoral site to bone deficient-sites within the same individual. Autografts are the most predictable osteogenic organic graft for osseous tissue regenerate. Grafts harvested from the iliac crest provide optimal osteoconductive, osteoinductive and osteogenic properties.<sup>8</sup> In animal studies, allografts have been found to possess bone-stimulating proteins and, consequently, osteoinductive properties.<sup>9</sup>

Patil *et al* in their study showed the use of human teeth as allograft are in accordance with various animal studies and case reports published in the 1980s. These studies have validated the osteoinductive potential of allogeneic, demineralized, lyophilized dentin. From a histological standpoint, WTA and DA particles were surrounded by vital bone with few areas of resorption. This indicates induction of new bone formation around these graft particles.<sup>10</sup> Bone allografts are reported to be less immunogenic than fresh-frozen bone allografts.<sup>11</sup> O'Sullivan *et al* found Evidence that all immunization may occur comes from a multicentre prospective study of patients receiving cortex-replacing, massive structural bone allografts. It was noted that donor-specific HLA sensitization occurred in 57% of the patients but subsequently had no demonstrable effect on bone graft incorporation or union.<sup>12</sup>

#### *Xenografts*

Xenografts consist of bone mineral from animals or bone-like minerals derived from corals or algae.<sup>13</sup> Fernandez *et al* in their study showed, two different xenogenic bone substitute materials were characterized and evaluated in vivo in sinus floor elevation procedures. This study compared BBM processing at high temperature (1200 °C)

and PBM processing at low temperature (130 °C) with different physicochemical properties as bone substitutes for healing in sinus lift procedures. In this paper, the effect of sintering temperature on the porosity, crystallinity, composition and phase purity of porous HA ceramics made of natural bone was studied and reported. The characterization of HAs ensured an overall understanding of the role played by the biological behaviour of these bone substitutes. Safety and efficacy of these bone substitute materials in the periodontal and peri-implant regeneration process.<sup>14</sup>

#### *Alloplastic*

An artificial bone replacement material that contains various calcium phosphate compounds made under sintering conditions that results in different physical properties and absorption rates.<sup>15</sup> Nappe *et al* showed there were no differences in the percentage of newly formed bone between the allograft and the alloplastic graft, and between the alloplastic graft and the xenograft. No significant differences in the percentage of residual particles between the three types of grafts were observed.<sup>16</sup>

### **TECHNIQUES FOR VERTICAL BONE**

#### *Block Graft Techniques*

To increase the vertical height of mandibular and maxillary edentulous ridges, only grating using bone blocks was first introduced in the early 1990s. Several autologous bone grafting techniques have been used for the treatment of severely resorbed edentulous mandible and maxilla. In particular, the use of barrier membranes for block grafts seems to significantly improve the clinical outcome.<sup>17</sup>

#### *Guided Bone Regeneration*

Guided bone regeneration (GBR) is a technique that works on the principle of separating particulate graft material from surrounding soft tissue to allow for bone regeneration, which occurs at a slower rate compared to soft tissues.<sup>18</sup> Vertical GBR is a sensitive technique that limits clinical success, and failure often occurs due to wound dehiscence.<sup>19</sup> Another limitation of vertical GBR is the ability to regenerate bone along the long axis of the applied force.<sup>20</sup> Specific problems associated with titanium membranes used for GBR are fibrous ingrowth through wide holes present in their structure and exposure of the membrane.<sup>21</sup>

#### *Autogenous tooth bone graft*

At Sarala *et al* study, the tissue structures of bone and dentin are different, the ratio of the organic and inorganic contents is similar (70% of mineral, 20% collagen, and 10% body fluids by wt). Dentin also contains some growth factors common to a bone, namely, insulin-like growth factor-II, bone morphogenetic protein (BMP), and transforming growth factor-beta. Autogenous tooth bone graft materials are of two types as follows: block and powder types. The block type of graft material demonstrates osteoinduction capacity through blood



wettability and also has osteoconduction capacity through space maintenance capability along with creeping substitution. The powder type is supplied based on various sizes of particles, porosity, blood wettability, osteoconduction, osteoinduction, and creeping substitution abilities. Both types can be used for the preservation of the extraction socket, esthetic restoration of the alveolar bone, restoration of perforated sinus membrane, and augmentation of early stabilization of implant. Furthermore, it supports brilliant bone regeneration through osteoinduction and osteoconduction capability and minimizes foreign body reaction due to genetic homogeneity. Autogenous DDM has shown potential applications in bone substitute and scaffold. The advantage is its low morbidity, easy handling, and great radiopacity and enhances bone-remodelling capabilities also there is the absence of antigenicity.<sup>22</sup> Autogenous tooth bone graft can be used in a particulate form or as a block graft. According to the literature, some study shows no significant difference in the amount of volumetric reduction between particulate bone and block bone grafts.<sup>23</sup>

Experimental and clinical studies on bone graft substitutes dentin grafts.

Dentin has been shown to be a potential carrier for human proteins and as grafting material because its biological composition is very similar to that of alveolar bone. Both tooth and alveolar bone are derived from neural crest cells and are made up of the same type I collagen. Al-Asfour *et al* in their study showed Demineralized xenogenic dentin only grafts show similar resorption characteristics as autogenous bone only grafts, being resorbed in a similar rate during 12 weeks. Bone formation occurs mainly in terms of replacement resorption in the interface between dentin and native bone. their findings indicate that dentin may be used as a bone grafting material, replacing bone or adding to the bone as grafting material.<sup>24</sup>

Atiya *et al* study, the result showed that liquid nitrogen-treated autogenous dentin has bone regeneration properties comparable to those of autogenous bone. This finding opens up a new avenue to explore the use of autogenous dentin prepared from clinically sound human teeth extracted for orthodontic reasons and/or surgical impaction. Furthermore, the materials used in the treatment of dentin with liquid nitrogen are uncomplicated and inexpensive. The present results indicate that the treated autogenous dentin graft could be used as a bone substitute for enhancing bone regeneration.<sup>25</sup>

Catanzaro *et al* in their study showed, in the defects with an implant of the dentin matrix in the shape of particles, an active process of resorption and substitution was observed, by which the particles are resorbed while they are substituted by the new osseous formation. In none of the studied cases was there a formation of cartilage previous to the osseous formation, the implants of the dentin matrix directly stimulate new bone formation. The fibro cellular tissue, which involves the particles, starts the resorption process of the dentin matrix from the surface. corroborate

the importance of the dentin matrix as an implant material in osseous surgeries; once it behaves as an excellent osteoinducing material, it is well tolerated by the organism and when in the shape of thin slices, it becomes adaptable to any surfaces and induces a ready osseous new formation without suffering resorption.<sup>26</sup> On the other hand, ankylosis of both dentin and enamel further showed the good biocompatibility of autogenous tooth as a bone substitute material.

Qin *et al* in their study showed the process of bone remodelling involved slow ankylosis between the bone and grafted tooth in the form of vascularization, resorption of the grafted tooth, and formation of new bone.<sup>7</sup> Moreover, it must be emphasized that the present surgical protocol considered a complete cementum removal and dentin exposure at the downward aspect of the roots to facilitate ankylosis at the defect site. The rationale for this procedure was based on previous findings that damages to the periodontal ligament or root surface were more likely to result in ankylosis and subsequently a replacement resorption. In contrast, to reduce a peripheral graft resorption, the cementum was preserved at the upward and lateral aspects of the roots.<sup>27, 28</sup>

In another study, Dentin blocks from human premolars extracted for orthodontic reasons were prepared by removing the crown, cutting the root into two halves and removing the pulp and periodontal ligament mechanically. Blocks sized 5–6 mm in diameter with a thickness of 3 mm were prepared and cleaned by being placed in 1% chlorhexidine for 10 min. The results of this study showed, it was possible to implant dentin blocks in rabbit tibia and achieve dentin-bone ankylosis after 3 months with osseous replacement resorption and with no signs of inflammation. The rabbit mandible however does not seem to be a predictable model for achieving ankylosis with dentin blocks.<sup>29</sup> When dentin has been experimentally implanted in direct contact with bone, fusion between bone and dentin has been reported with replacement resorption of the dentin by bone.<sup>30</sup> Table 1 shows a summary of Dentin articles.

## Conclusion

There are a plethora of techniques with various combinations of natural and synthetic graft materials that can be utilized for achieving vertical alveolar bone augmentation. The materials used in the treatment of dentin are uncomplicated and inexpensive. The present results indicate that the autogenous dentin graft could be used as a bone substitute for enhancing bone regeneration.

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	Article Source	Study Design	Statistically Significant Finding
<b>Dentin grafts</b>	<i>Gual-Vaqués P,(2018).</i>	Demineralized xenogenic dentin and autogenous bone as onlay grafts to rabbit tibia. <i>Implant dentistry</i>	Evaluate the reliability of the autogenous tooth bone graft material applied to alveolar ridge augmentation procedures
	<i>Al-Asfour A. (2017)</i>	Demineralized xenogenic dentin and autogenous bone as onlay grafts to rabbit tibia	Demineralized xenogenic dentin onlay grafts showed similar resorption characteristics as autogenous bone onlay grafts, being resorbed in a similar rate during 12 weeks. New bone formation occurred mainly in terms of replacement resorption in the interface between dentin/bone graft and native bone.
	<i>Atiya BK, (2012)</i>	Autogenous Dentin as Bone Substitute	That liquid nitrogen-treated autogenous dentin has both osteoconductive and osteoinductive properties and therefore has potential as a bone substitute
	<i>Lee H-J (2017)</i>	Osteogenic Potential of Demineralized Dentin Matrix as Bone Graft Material	The DDM had an enhanced osteogenic potential as a bone substitute for bone augmentation procedures in the dental and medical fields.
	<i>Andersson L,(2009)</i>	Studies on dentin grafts to bone defects in rabbit tibia and mandible; development of an experimental model	Investigate if dentin can be used as a graft in bone defects in an experimental rabbit model.
	<i>Schwarz F(2016)</i>	eriodontally diseased tooth roots used for lateral alveolar ridge augmentation.	PM-P autografts may reveal a structural and biological potential to serve as an alternative autograft to AB.
	<i>Qin X, (2014)</i>	Using rigidly fixed autogenous tooth graft to repair bone defect: an animal model. <i>Dental Traumatology</i>	Rigid fixation of autogenous tooth could serve as a novel approach for the repair of bone defect.
	<i>Schwarz F(2016)</i>	Extracted tooth roots used for lateral alveolar ridge augmentation: a proof-of-concept study. <i>Journal of clinical periodontology</i>	Extracted tooth roots revealed a structural and biological potential to serve as an alternative autograft to autogenous bone. A higher exposure rate may be expected when using endodontically treated teeth.
	<i>Al-Asfour A,(2014)</i>	Host tissue reactions of non-demineralized autogenic and xenogenic dentin blocks implanted in a non-osteogenic environment	Dentin can possibly act as a slow-releasing carrier of bone morphogenic proteins (BMP), and this property of dentin has been proposed to be used as an alternative or supplement to bone grafting in the maxillofacial region

Table 1: Dentin articles