

# TOOTH BIO-BANKING

## Abstract

Tooth bio-banking (Tooth banking) has emerged as an innovative practice globally, leveraging the unexplored potential of dental tissues; including enamel, dentin, and dental stem cells, for future therapeutic applications. Utilization of tissues derived from dental structures can provide a natural solution for the regeneration and rehabilitation of damaged or lost human tissues. Practice involves the collection, processing, and preservation of dental tissues, such as extracted teeth for educational, restorative, research testing, and as bone graft material. In today's times, the primary focus of tooth bio-banking includes the extraction of dental pulp as a valuable source of stem cells. With its regenerative properties and the ability to differentiate into various cell types it makes for a promising solution for diverse medical interventions, including tissue engineering and organ regeneration. There is a dire need to create an awareness regarding the other applications and potential benefits of the tooth bio-banking system among medical and dental professionals as well as patients.

The chapter also addressed the need for standardized practices surrounding the tooth bio-banking system and the ethical considerations and regulatory frameworks required for its establishment. The tooth bio-banking system can have a transformative impact on the landscape of regenerative and restorative dentistry, opening avenues for novel therapeutic interventions and paving the way for a more personalized and effective approach to healthcare.

**Keywords:** Biobank, Biological Restorations, Bone Graft Material, Dental Education, Dental Research, Human Tooth Bank, Stem Cell Banks, Tooth Bank, Tooth Bio-Bank.

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## BIOBANK

‘A collection of biological material and the associated data and information stored in an organized system for a population or a large subset of a population’

*Organisation for Economic Cooperation and Development (OECD) (2006)*

### I. INTRODUCTION

In recent times, both government and private sector organizations have become interested in the banking of human tissues for future therapeutic uses because it provides real-time solutions to complex health-related challenges involving various human body tissues.

Currently, stem cell banks and blood banks are established practices in the field of modern medicine. Blood banking system is an age-old, established practice that provides life-saving advantages to patients as an affordable, safe, effective, and easily available solution. Blood banks aim to provide blood and its related components to patients in times of urgency. Blood banks are a very well-established system, and various organizations like the World Health Organisation (WHO) and the US Food and Drug Administration (FDA) have constantly regulated their function and safety issues in the public interest.

Advancements made in regenerative medical science and its clinical applications have led to exponential growth and increased awareness of stem cell banking. Currently, stem cell collections from tissues like bone marrow, blood, foetal material, and the umbilical cord are established practices with practical and ethical concerns. The prospective study on postnatal cell populations produced from dental pulp tissue conducted by *Gronthos and Shi* two decades ago opened new avenues for researchers in field of stem cells and gave dentistry a direction towards regenerative medical science.

Today, it is critically important to set up tooth banking systems (TBS) with suitable protocols and facilities not just for stem cell extraction but also to meet the demand for extracted teeth used as teaching and learning resources in dental schools, research projects, and clinical restorative needs.

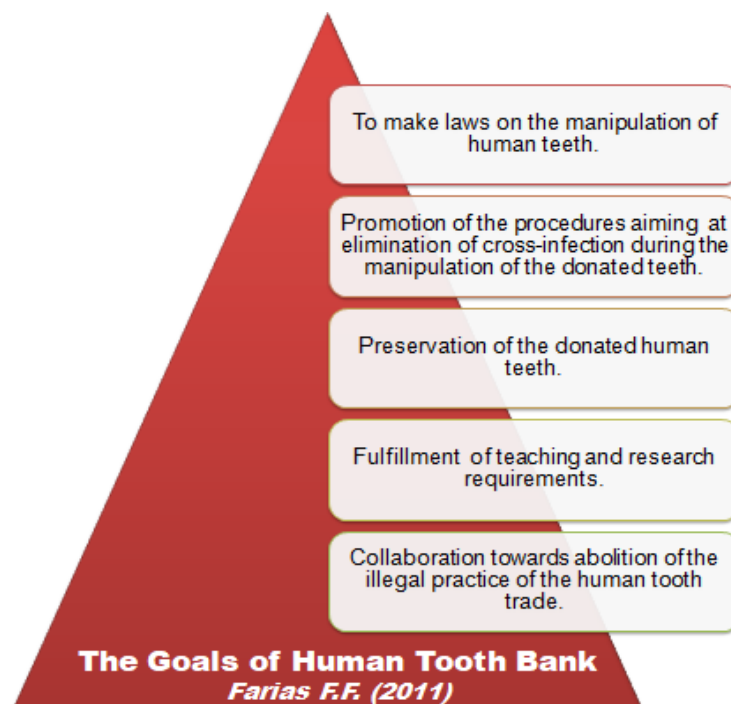
Human Tooth Bank (HTB) is a nonprofit organization affiliated with a college, university, or any other organization aimed at satisfying academic requirements by donating human teeth for research activities and preclinical laboratory training of students.

*Nassif AC, Tieri F, Ana PA, et al. 2003*

## II. NEED OF TOOTH BIO-BANKING SYSTEM

Over the past decades, Dentistry has evolved in terms of better clinical techniques, dental material formulations, regenerative therapies, and explorative research. This has enhanced the utility and need for extracted human teeth. Therefore, with the substantial increase in demand for extracted teeth, setting up a tooth bio-banking system becomes essential.

The basic concept of human tooth banking was developed in 1981 as there was a continuously growing demand for extracted teeth for research purposes and also to combat and abolish illegal and hazardous procurement.



- 1. Stem Cell Therapies:** Oral tissues provide potential sites for the collection of stem cells. Dental stem cells (DSCs) include adult dental pulp stem cells (DPSC), human exfoliated deciduous teeth or stem cells from exfoliated deciduous teeth (SHED), periodontal ligament stem cells (PDLSC), alveolar bone stem cells (ABSC), stem cells from the apical papilla (SCAP), tooth germ progenitor cells (TGPC), Dental follicle stem cells (DFSC), oral epithelial tissue, gingiva, and salivary glands. Amongst the above mentioned types of stem cells, stem cells from exfoliated deciduous teeth (SHED) are the most preferred, as they are easily available and safe. Dental stem cells (DSCs) have the potential to differentiate into adipocytes, neural cells, osteocytes, chondrocytes, and myocytes. Also, they can be utilized for regeneration of dentin, periodontal ligament, cementum, pulp, salivary gland tissues, the temporomandibular joint, and whole tooth regeneration. India is one of the few nations with official regulations governing research using stem cell products and derivatives (SCPDs). National Guidelines for Stem Cell Research were recently published in 2017, after ICMR and DBT modified the current regulations jointly. The document's primary guiding principle aimed to stop the rampant commercialization of untested stem- cell therapies and to generate new information based on good scientific reasoning while taking all ethical issues into account.

In the past, stem cell banks have collected bone marrow and placental cord blood-derived stem cells, but recent years have seen exponential growth in dental stem cell banking, particularly in India, the United States, and the United Kingdom. Currently, there are no proper guidelines, particularly for tooth banking systems utilized for stem cell therapies, as most of the regulations focus on stem cell banking. Also, there is a lack of public funded tooth banking systems, whereas the private sector focuses primarily on the preservation of stem cells. Therefore, establishing properly structured tooth banks would help in a safe, ethical, and legal way of stem cell procurement, storage, and utilization in a wide range of systemic diseases and regenerative research.

- 2. Education and Research:** Utilization of extracted human teeth (EHT) is an integral part of undergraduate and postgraduate dental educational training and learning programmes worldwide. The basic utilization involves understanding the internal anatomy and histology of the tooth, tooth preparations for restorative purposes, endodontic procedures, research related to dental materials and procedures, and the restorative material itself. In spite of the availability of artificial teeth and simulators, the use of EHT for teaching, learning, and research is irreplaceable because of their cost effective availability. Also, artificial teeth or simulator systems fail in the exact replication of required biomechanical properties and tactile perception, similar to a real clinical case situation.

EHT used for research purposes cannot be replaced by artificial and expensive methods like finite element analysis or simulators, and they still remain the gold standard choice for laboratory research. Development and in-vitro or ex-vivo testing of various properties of newer restorative material formulations and techniques like evaluation of fracture strength, bonding, microleakage etc. carried out on EHT provide more realistic and clinically relatable observations. The major concerns related to the use of EHT for research purposes include illegal and unethical procurement, cross contamination, availability, and improper storage, which may affect the quality of the research outcome. A properly established tooth banking system can address all these concerns and provide researchers with good quality EHT.

- 3. Biological Restorations:** Restorative dentistry focuses on the idealistic rehabilitation of the biomechanical functions and properties of diseased or injured teeth. Though there is exponential growth and improvement in the restorative material formulations, all the contemporary restorative materials cannot match the exact bio-mechanical property of a natural tooth. Numerous researchers have suggested the use of natural enamel and dentine for restorative purposes. The choice of using natural tooth substances for restorative purposes presents as a gold standard when compared to synthetic restorative materials, and it is called 'Biological Restorations'.

'Biological Restorations' can be defined as the procedures in which a sterile natural enamel and/or dentin tissue is used to reinstate the carious, fractured, missing and defective structures of the tooth, so as to re-establish the Bio- functional requirements, and maintain a healthy stomatognathic system.

*Gunwal, M. K. et.al. (2022)*

Clinical application of biological restorations presents a wide range of treatment alternatives for deciduous and permanent dentitions, including restoration of carious teeth, defects, and fractured teeth. Also, treatment alternatives like inlays, veneers, post and core, full crowns and abutments can be obtained. The availability of natural teeth in the appropriate shape and shade is a prerequisite for biological restorations. Also, the patients' and/or parents' consent for the procedure is of prime importance.

Biological restorations provide a natural, conservative, time saving, cost-effective, and aesthetic restorative solution. In spite of its biological and economical benefits, awareness and clinical applications of 'Biological Restorations' are limited due to lack of knowledge regarding the procedure and also due to lack of easy and safe availability of compatible natural teeth. Clinically, it is not always possible to use the patient's own fractured fragment or donor tooth for the reattachment or biological restoration procedure. Therefore, establishing a tooth banking system for proper collection, cleaning, sterilization, storage, and distribution of natural tooth substance is pivotal. Establishment of a tooth banking system will encourage clinicians to perform biological restorations in routine clinical practice as there will be ethical availability of extracted teeth without concerns of cross-contamination. Also, it will provide a properly stored, wide range of extracted teeth of different forms and shades, matching the clinical requirements.

- 4. Bone Graft Material:** The field of medical sciences has been using bone graft materials for decades, with the earliest noted evidence in the year 1688, when a human cranial defect was corrected with the use of cranial bone graft from a canine (dog). The field of dentistry has seen an exponential boost in the use of bone graft materials due to the increased need for implants and the repair of a range of defects arising from traumatic injuries, infections, and cancers. Various types of grafts are available, including autograft, allograft, xenograft, phytogenic material, synthetic bone substitute materials, hydroxyapatite, tricalcium phosphate ceramics, biphasic calcium phosphate ceramics, bioactive glass, calcium phosphate cements, calcium sulphate, polymers, metals (magnesium, strontium, zinc, and silicon), composite bone substitute material, growth

factor-based bone substitutes, and bone substitutes with infused living osteogenic cells.

Despite the emergence of various bone substitute in recent years, autografts continue to be the gold standard for grafting materials because they possess all four essential biological qualities needed: osseointegration, osteogenesis, osteoconduction, and osteoinduction. However, autografts present some disadvantages, including the requirement of a secondary surgical site, increased postoperative visits, injury and morbidity at the donor site, scarring, a high cost, and limited availability.

Researchers are working restlessly to overcome these limitations and the path breaking research presented by Yeomans and Urist on human dentin's bone-inducing properties has opened up a completely new avenue in the field of bone grafting materials.

Tooth is a complex composite structure containing inorganic calcium phosphates, organic collagen type I, water, growth factors like bone morphogenic proteins (BMPs), and other proteins with the capability to induce bone resorption and generation processes. The chemical composition of dentin is similar to that of bone, where dentin contains 70– 75% inorganic, 20% organic, and 10% water, while bone contains 65% inorganic and 35% organic content. Dentin contains 70% hydroxyapatite, which is low crystalline in nature and similar to that of bone appetite. Research has shown that when compared to bone, teeth present with properties like osteoconduction, osteoinduction, and osteogenesis and similar histological properties, which make them a potential alternative to conventional bone graft material. In 2009, the Korean Tooth Bank (KTB) in Seoul, Korea, developed novel bone graft material from patients own extracted teeth. The hospital tooth bank (HTB) in Seoul National University Bundang Hospital 2010 stored and used tooth-developed bone graft material following the guidelines established in accordance with the tooth bank's definition.

Clinical research on extracted tooth powder or block as bone graft material for dentoalveolar repair concludes that they are effective bone graft material and provide successful clinical, radiographical, and histological outcomes. This development also highlights the dire need for the establishment of a proper tooth banking system for the safe and economical use of extracted teeth.

### **III. BIOSAFETY AND ETHICAL CONCERNS FOR TOOTH BIO-BANKING**

Extracted human teeth are mostly procured from dental clinics, hospitals, institutes, and, in some countries, also from cemeteries. All of these practices raise serious ethical issues. The unknown origin of EHT acquired for educational, research, or restorative purposes leads to illegal marketing and an increased risk of cross contamination. The establishment of a proper tooth banking system can eliminate the risk of cross contamination and illicit trade in EHT.

Concerns are raised regarding the use and handling of extracted tooth as there is potential contact with the blood-borne microbial/pathological agents. This concern is not only associated with the clinicians but also with the individuals collecting the EHT, including students and researchers. In particular, it is important to consider pathogens like the hepatitis B and C viruses (HBV and HCV) and the human immunodeficiency virus (HIV).

International agencies like the Occupational Safety and Health Administration (OSHA) and the Centre for Disease Control and Prevention (CDC) have considered and regulated the proper handling and storage of EHT for the prevention of cross contamination. Human teeth that have been extracted are viewed as a potential source of blood-borne infections by OSHA, and the CDC made suggestions about suitable approaches to preparing and storing extracted human teeth for ex vivo use. Apart from cross-contamination, there is one more concern related to the consent of the patient or donor of teeth regarding its use after the extraction process.

Sterilizing the extracted tooth appropriately provides the best solution for concerns related to biosecurity. Various methods are recommended for the purpose of sterilization and disinfection which includes use of autoclave, boiling, iodine-based solution, hydrogen peroxide, quaternary ammonium compounds, glutaraldehyde, formaldehyde, thymol, sodium hypochlorite (NaOCl), ethylene oxide and gamma radiations. According to the literature, the most efficient ways to sterilize an extracted tooth are with 10% formalin, 5.25% sodium hypochlorite, and use of autoclave from 20-40 minutes.

One more concern regarding the utilization of EHT is illegal procurement at a high cost and its unknown origin. Establishing the practice of tooth banking system can completely eliminate the process of illegal and unsafe procurement of extracted teeth and, at the same time, provide critical information to both the donor and the individual or recipient procuring them.

#### **IV. CONSIDERATION FOR TOOTH BIO-BANKING SET UP**

- Designated collection centres should be established for the safe collection of extracted human teeth to eliminate unethical and illegal utilization. The initial disinfection procedure should be performed at the collection centre using personal protection equipment.
- Mandatory written informed consent should be obtained from the donor with a detailed medical history to avoid the chances of cross contamination with highly transmissible diseases.
- Proper transportation of EHT to the banking facility should be carried out in safe containers while maintaining biosafety and special consideration should be given to those extracted teeth which are to be used for stem cell banking.
- EHT should be evaluated microscopically and segregated according to the intended purpose. Also, sample processing should be done accordingly.
- All the discarded extracted teeth should be handled and disposed off according to biosafety norms.

#### **V. CONCLUSION**

Tooth banking is a promising and innovative approach for preserving extracted dental teeth and related tissues for the purpose of dental stem cell preservation and as a resource material in dental teaching, in-vitro research, biological restorations, and developing bone graft materials. The establishment of a tooth banking system can potentially unlock the various medical and therapeutic benefits of extracted teeth and pulp stem cells. However, there is an absolute lack of awareness in clinicians and patients regarding safe and effective

utilization of extracted human teeth. Also there are no recognized guidelines regarding establishment and functioning of tooth bank.

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