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# Biological restoration: newer way of esthetic restoration- A review

[1]Dr Abhishek Anand, Dept. of Pedodontics and preventive dentistry, Assistant professor, Vananchal dental college and hospital, Garhwa, Jharkhand, India

[2]Dr Jalendra Prasad, Dept. of pharmacology, Associate Professor, Buddha institute of dental science & hospital, Patna, Bihar, India

**Corresponding Author:** Dr Abhishek Anand, Dept. of Pedodontics and preventive dentistry, Assistant professor, Vananchal dental college and hospital, Garhwa, Jharkhand, India

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**Abstract**

Dental caries and trauma are the most prevalent disease in humans, especially in early childhood. Restoration to reestablish the anatomy of traumatized and extensively damaged teeth should be done skillfully. Premature loss of deciduous tooth may lead to loss of vertical dimension of occlusion, tongue thrusting and mouth breathing habits which further resulting malocclusion in future. Satisfactory restoration for improving esthetics along with management for speech and phonetics has been a challenge for pediatric dentistry always. Increasing demand for esthetics has led to innovation and development of newer treatment modalities as an alternative technique for such problems. In an attempt to widen the treatment options tooth structure is used as restorative material to rehabilitate the severely damaged tooth. Such a new technique was termed as Biological tooth restoration.

The article aims at reviewing the evolution, techniques and various outcomes of biological restoration

**Keywords:** Autogenous, Biological tooth restoration, Bio mimetic property, Cryopreservation, Hank's Balanced Salt Solution, Hetrogenous

## Introduction

Since the mouth is one of the focal points of the face, it comes as no surprise that a smile plays a major role in how we perceive ourselves, as well as in the impression we make on the people around us. A charming smile can open doors and knock down barriers that stand between you and fuller, happier & cheerful life…!!!

Trauma and decay are the most prevalent condition in humans especially during early childhood. The treatment to skillfully restore these teeth is a challenge to our community. In earlier days, the treatment option for these conditions was the expedient removal of the involved teeth but exodontia compromises esthetics and does not justify a child's beautiful smile. Hence, the various

treatment modalities to retain and restore the tooth come into play like composite or GIC restoration which gives us the advantage of esthetics. But these restorative materials have certain disadvantages also like loss of natural tooth structure while tooth preparation, technique sensitivity, time consumable, less economic feasibility, tedious clinical procedure, patient cooperation for oral hygiene maintenance, and are also prone to induce internal dentinal stress which results in inefficient strength and retention.

To overcome the downside of conventional restorative procedure, other esthetic treatment options like strip crowns, cheng crowns, dura crowns, glasstech crowns, pedo jacket crowns and polycarbonate crowns came into play and recently a newer technique i.e. biological tooth restoration is added as an alternative restorative procedure.[1]

Biological restorations came in play when Chosack and Eidelman in 1964 reattached broken maxillary incisor to the traumatized tooth.

In 2010 Patrica et al defined biological restoration as an alternative technique for reconstruction of extensively damaged teeth that provides highly functional and esthetic outcomes.[2] Biological restoration is a simple procedure with a relatively short chair time along with it allows preservation of internal dentinal wall and also does not promote dentin stress. It provides the excellent adhesion to the remaining tooth structure and composite resin at a very low cost.[3]

Biologic tooth restorations have demarcating advantages like provision of natural esthetics in the form of color, morphology, translucency match and psychological benefit to the patient. Less time consumption, economic feasibility, total biocompatibility, preservation of internal dentin walls of the root canal, resilience comparable to the original tooth, excellent adhesion to the tooth structure and composite resin and reduction of dentin stress add to its beneficial aspects along with distinguishing boon like greater tooth strength and greater retention of these posts as compared to pre manufactured posts.

**Definition**

Biological restoration is gradually becoming as a current treatment option in dentistry. As it is a new evolution in dentistry it is defined by various authors as :

In 2003 Mandroli PS defined biological restoration as a promising alternative technique to prosthodontic restoration for primary teeth severely destroyed due to caries.[4]

In 2010 Patrica et al defined biological restoration as an alternative technique for reconstruction of extensively damaged teeth that provides highly functional and esthetic outcomes.[5]

In 2012 Shivani Mathur defined biological restoration as a simple technique which provide excellent esthetics as well as preserves natural tooth color compared to composite resins and stainless steel crowns, allow the preservation of sound tooth structure and has low cost. The enamel of the biologically restored tooth has physiological wear and offers superficial smoothness and cervical adaptation with those of surrounding teeth.[6]

**Ideal requirement**

Every treatment option has some criteria for the selection of the restoration. Biological restorations follow certain criteria as restorative materials, such as :

- Fracture fragments should be intact and free from any cracks to enhance the strength of restorations.
- The patients should have favorable occlusion without any parafunctional habit which maximize the strength and also stimulate the appearance of natural teeth.
- The field should be properly isolated to prevent the contamination during attachment of fragment.

- In order to maintain the longevity of restoration patient has to maintain the good oral hygiene.
- There should be a regular follow up at regular interval of time.[7]

**Rationale of biological tooth restoration**

- To achieve biologically compatible and clinically acceptable restorations for parents and patient.
- To maintain the form and function of tooth.[8]

**Indication**

- Extensive carious lesion[8,9]
- Following pulp therapy[5,8]
- Bio-mimetic property[10,11]

**Contra-indication**

There is no absolute contraindication to biological tooth restoration. But if patient does not want the fragment from other people's teeth in their mouth and refuse to receive the treatment.[5]

**Classification of biological tooth restoration**

As the biological restoration is a latest trend of practice nowadays, it can be classified as following:

1. Based on the type of tooth used (Tavano KTA et al, 2009)

- Autogenous
- Heterogenous

Autogenous: when patient's own fracture fragment is available and is in satisfactory condition.

Hetrogenous: when fracture fragments are obtained from tooth bank or from any donor.[12]

2. Based on the use (Mandroli PS, 2003)

- Biological restorations used as a crown.
- Biological restorations used as a post.[4]

3. Based on the location (Santos and Bianchi, 1991)

- Biological restoration used in anterior region.
- Biological restoration used in posterior region.[4]

**Autogenous tooth restoration**

The use of natural teeth fragments is an efficient method of restoring teeth. Biological restoration takes on special importance in restorative dentistry as they can be used in the form of restorative material, veneer, crown and post. The technique of bonding tooth fragments was first proposed by Chosack and Eidelman in 1991 to repair permanent teeth with the patient's own fractured teeth which is also called as autogenous tooth fragment.[9]

When patient's own fracture fragment is available and is in satisfactory condition (without any fracture) which can be used for the biological restoration is defined as an autogenous tooth fragment.

The dental surgical intervention of this technique was first documented by Abulcassis in 1050. However, the first recorded surgery with details about tooth bud transplantation was performed by the French dentist Ambroise Pare in 1564. But the detailed study on autogenous tooth transplantation was documented in 1954 by M.L. Hale.[13]

The donor tooth should be positioned such that extraction socket will be as atraumatic as possible. Abnormal root morphology, which makes tooth removal exceedingly difficult and may involve tooth sectioning, is contraindicated for this surgery.

Schwartz et al in 1985 yielded success rates of only 76.2% at 5 years and 59.6% at 10 years. Similarly, Pogrel found that his success rate for 416 autotransplanted teeth was 72%.[14]

**Indications**

Autogenous tooth fragments are indicated in traumatic tooth loss, tumors, teeth with bad prognosis, in case of developmental anomalies of teeth and congenitally missing teeth.[13]

**Contra-indications**

Autogenous tooth fragments are contra-indicated in patients with cardiac anomalies, poor oral hygiene, lack of self-motivation and insufficient alveolar bone support.[13]

**Advantages**

Autogenous tooth fragment has an important role in the replacement of missing teeth of young patients due to the contra-indication of osseointegrated implants for them. The use of biological restoration that represents a feasible option for the strengthening of the root canal, have more potential advantages:

- The auto transplanted tooth has the capacity for the preservation of alveolar ridge because they provide the functional adaptability to the tooth.
- They are advantageous as comparison to osseointegrated implants that are stationary and do not erupt, resulting in infraocclusion.
- They are bio-compatibile and provide better adaptation, favoring greater tooth strength and greater retention of these posts as compared to pre-manufactured posts.
- Offers excellent adhesion to the tooth structure and composite resin and that too at a low cost.[5]

**Disadvantages**

The use of natural, extracted teeth (homogeneous bonding) for restorations has some limitations, such as

- In spite of being simple, the technique requires professional expertise to adequately prepare and adapt natural crowns to the cavity.[5]
- Reattachment may sometimes lead to visible demarcation.
- Reattached tooth may loosen from original tooth due to masticatory force involved.
- The use of very thin fragments where all the dentin is removed lowers the fracture resistance of bonded fragment.[7]

However, all these factors are not contra-indications of the techniques.

**Sterilization and Storage**

J.O. Andresean in 1981 showed that the viability of periodontal ligament exposed to the extraoral space decreased rapidly after 18 minutes. The prognosis of auto transplanted teeth is facilitated by an optimum periodontal, pulpal, and periapical condition.[15]

The storage medium can contribute to the maintenance of the chemical, physical and mechanical properties of extracted human teeth tissues and influence the outcomes of the researches.

The use of saline solution, water, and disinfectants (0.12% chlorhexidine solution, sodium hypochlorite, sodium azide) are practiced. The tooth saving media (HBSS) is recommended by the Centers for Disease Control and Prevention (CDC).[16]

Hank's balanced salt solution (HBSS) [Fig. 1 & Fig. 2] can be used to store tooth at the temperature of $4^{o}C$. It has all of the metabolites such as calcium, phosphates ions, $K^{+}$ and glucose which are necessary to maintain normal cell metabolism for long periods of time. 90% of cells stored in Hank's balanced salt solution for 24 hours maintain their normal vitality and it decreases to 70% after four days. This solution is available with the trade name of "Save-A-Tooth" [Fig. 8], which is used for storage, preservation and regeneration of tooth root cells. Though it maintains the vitality of tooth it doesn't disinfect it effectively.[17,18]


Fig.1: HBSS

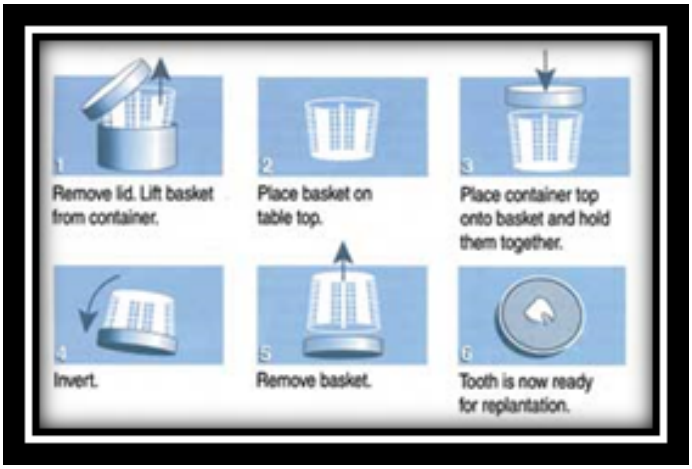


Fig:2 Storage in HBSS

**Hetrogenous tooth fragments**

When the fracture tooth fragment is obtained from some other patient's extracted tooth or from tooth bank which can be used for biological restoration is defined as hetrogenous tooth fragment.

**Sterilization and Storage**

The Centers for Disease Control and Prevention (CDC) and the American Dental Association (ADA), has recommended sterilization through saturated steam under pressure, for 40 minutes, of extracted human teeth to be employed in teaching and research. This method does not alter the physical properties of the dental tissues and does not compromise the goals and/or results of the application of these teeth in teaching, research or therapeutics.[16]

Dominici et al in 2001, did an invitro study in which they have inoculated extracted human teeth with Bacillus stearothermophillus to assess different methods of sterilization and disinfection of human teeth for dental teaching. It was verified that the exposure to 10% formalin for 7 days and autoclave at 115ºC for 40 minutes at 20 psi (1.38 bars) were the most efficient methods. The use of 2% glutaraldehyde, sodium hypochlorite at the concentrations of 5.25%, 2.6% and 1.3% and 0.28% quaternary ammonium for disinfection purposes were not indicated because they were not efficient in eliminating Bacillus stearothermophillus.[2,19]

Gamma radiation is efficient, yet it is not a common method used within the institutions because of its high cost.[2]

**Tooth bank**

A human tooth bank is a non-profit institution that is associated with a college, university or other such institution that provide for didactic, scientific and clinical use. Its purpose is to fulfill academic needs for research and laboratory training for students. It has strict control on separation and stocking of teeth and maintenance of donors and beneficiaries records.

The concept of Human Tooth Bank (HTB) appears in 1981, through the execution of a research which required a tooth from a service that assures the quality of the dental organ. HTB was first adopted by the School of Dentistry of the University of Sao Paulo, Brazil, in the discipline of Pediatric Dentistry in 1996. Currently in Brazil, there are 60 tooth banks within public or private higher education institutions.[2]

According to the proposal of Farias in 2011, there are certain goals such as[20]

1) At such a low temperature, water exists only in solid state and no known biological reactions can takes place. Water solidifies into a crystalline structure which is known as ice when it is cooled below the freezing point. Because of the lesser density of ice as compared to water, ice crystals occupy a greater volume. As more water within the cells begins to solidify into ice, the shearing force and pressure which is exerted on the intracellular organelles leads to considerable damage. Therefore, first goal is the prevention of ice crystals formation.
2) As more and more water is converted to ice, the concentration of unsolidified liquid phase increases. This can be toxic to the intracellular proteins and is known as “solution effects”. Hence, the second goal is avoiding this effect.
3) Rewarming of the cryopreserved tissue results in the melting of the ice and the release of free water, which reduces the osmolarity of the surrounding solution. Slow rewarming leads to thawing of the water and recrystallization causing further damage. On the other hand, rapid rewarming leads to a sudden drop in the extracelluar osmotic pressure causing a rapid shift of free water in and out of the cell. This further leads to swelling and cell damage. This is called “osmotic shock” and its avoidance is a third major goal.

These goals were kept for a HTB to meet the laws on the manipulation of human teeth, promote the adoption of procedures aiming to eliminate the cross-infection during the manipulation of the teeth donated, preserve the human teeth donate and collaborate to the banishment of the illegal practice of the human tooth market.

The tooth bank functions within the framework of tissue bank’s activity in terms of cryopreservation.

**Cryopreservation**

Cryopreservation is a process where cells or whole tissues are preserved by cooling to low sub-zero temperatures, such as (typically) 77 K or −196°C (the boiling point of liquid nitrogen). At these low temperatures, any biological activity, including the biochemical reactions that would lead to cell death, is effectively stopped.

Dimethylsulfoxide (DMSO) has been commonly used in many studies as the ingredient for the freezing medium. DMSO prevents cytoplasmic membrane destruction from intracellular ice crystal formation during the freezing process.[15]

Bartlett and Reade in 1972 were the first scientists to experiment on the cryopreservation of tooth material. Their experiments suggested that the cells in the teeth can survive the freezing process and that they can be cryopreserved.[20]

**The principles of cryopreservation**

1. Prevention of ice crystal formation

To maintain long-term viability after a long-term storage, living cells must be brought into a state of suspended animation in which they can remain for indefinite periods of time and from which they can be brought back to viability at some point in the future. The temperature that is generally used for the storage of mammalian cells is -196°C. The temperature of liquid nitrogen appears to be adequate for these purposes. At such a low temperature, water exists only in a solid state and no known biological reactions can take place. Water solidifies into a crystalline structure which is known as ice when it is cooled below the freezing point. Because of the lesser density of ice as compared to water, ice crystals occupy a greater volume. As more water within the cells begins to solidify into ice, the shearing force and the pressure which is exerted on the intracellular organelles leads to considerable damage. Therefore, one of the principles of cryopreservation is the

prevention of ice crystal formation. More and more water is converted to ice, the concentration of the unsolidified liquid phase increases. This can be toxic to the intracellular proteins and is known as 'solution effects'.

2. Avoidance of solution effects

Avoidance of solution effects is the second principle of cryopreservation. Rewarming of the cryopreserved tissue resulted in the melting of the ice and release of free water, which reduces the osmolarity of the surrounding solution. Slow rewarming leads to thawing of the water and recrystallization causing further damage. On the other hand, rapid rewarming leads to a sudden drop in the extracellular osmotic pressure causing a rapid shift of free water in and out of the cell. This further leads to swelling and cell damage. This is called 'osmotic shock', and its avoidance is a third major goal of successful cryopreservation.

3. Avoidance of osmotic shock

In order to prevent these consequences from occurring, some chemical substances which have been used are called as cryoprotectants. The type, concentration, equilibration and the dilution of the cryoprotectant as well as its freezing rate, is known to influence the cryopreservation of the tissues. These components need to be optimized for specific cells and tissues.

The cryoprotectants can be classified into permeating and non-permeating agents.

a) Permeating Agents

These are small molecules which readily permeate the cell membranes. They impede ice crystallization by forming hydrogen bonds with the water molecules. At a high concentration they hinder the formation of ice crystals, leading to the formation of a solid glass like vitrified state where water solidifies but does not expand, thus preventing the formation of ice crystals. These agents also dilute the surrounding electrolytes, thus preventing the solution effect on the cells. Ex: propylene glycol (1,2 propanediol, PROH).

b) Non-permeating Agents

In contrast to the permeating cryoprotectants, non-permeating cryoprotectants remain extracellular. They draw free water from within the cell and cause dehydration of the intracellular space. They reduce the formation of ice crystals when used along with permeating cryoprotectants and also play an important role during thawing. Therefore, the freezing and thawing protocols commonly use a high concentration of non-permeating cryoprotectants during the thawing phase.[20]

Application of cryopreservation in pediatric dentistry

i. Avulsed incisors, impacted third molars, canines, premolars which are extracted for orthodontic purposes and exfoliated deciduous teeth can be banked.
ii. The exfoliated or extracted deciduous teeth can be cryopreserved and the stem cells can be isolated to be used for different purposes. Like organ and stem cell banking, tooth banking is also evolving to produce a possible reserve of dental tissues.
iii. The cryopreservation of cells and tissues is a promising tool for the preservation of cells which have to be used for biological restoration. This technology opens a new avenue for preserving one's own cells and tissues to be used at a later time.[20]

**Benefits of tooth bank**

i. Tooth can be used as a current stem cell application for cancers, gum disease, immunodeficiency disorder, and cardiovascular, metabolic disease.
ii. Tooth also can be used for emergency application such as tooth loss, jaw bone regeneration, facial reconstruction.[20]

Tooth banking is currently not very popular across the world but the trend is gaining acceptance mainly in the developed countries.

**International tooth bank**

i. BioEden (Austin, Texas, USA) has international laboratories in UK (serving europe) and Thailand (serving South Asia) with global expansion plans.

ii. Stem cell banking companies like Store-A-Tooth (Provia laboratories, Littleton, Massachusetts, USA) and Stem Save (Stemsave Inc, New York, USA) are also expanding their horizon internationally.

iii. In Japan the first tooth bank was established in Hiroshima University and the company was named as "Three Brackets" (Suri Buraketto) in 2005.

iv. Nagoya University (Kyodo, Japan) also came up with a tooth bank in 2007.

v. Tapei university in collaboration Hiroshima University open nation's first tooth bank in September in 2008.

vi. Norwegian tooth bank (a collaborative project between the Norwegian Institute of Public Health and the University of Bergen) set up in 2008 is collecting exfoliated primary teeth from 1,00,000 children in Norway.[21]

**National tooth bank**

i. Not last but the least, Stemade introduced the concept of dental stem cells banking in India recently by launching its operations in Mumbai and Delhi.[21]

While the "tooth bank" may not be most common place for treatment method today but there may come a day in the near future where it is common knowledge to deposit teeth in the bank!!!

Treatments performed by using biological restoration

- Biological restoration as a restorative material[14]
- Biological restoration as a veneer[13]
- Biological restoration as post & core followed by biological crown[5]

**Limitation**

Use of natural tooth for different aesthetic procedure has certain limitations and it can't be used for each and every case. These limitations are

- Prolonged dehydration of the fragment may present aesthetic problem.
- Inability of reattachment/ re-approximation of fragment.
- Reattached tooth may loosen from the original tooth due to masticatory force involved.
- Reattachment may sometimes lead to visible of demarcation.[22]

**Advantages**

- The technique is simple which allows the preservation of sound tooth structure.[2,18,17,14]
- It provides excellent esthetics as compared to composite resins and stainless steel crowns ,
- especially regarding translucency.[14]
- It has low cost as compared to other restorative material and thus, it is economical.[2,18,23,14]
- Using tooth fragments as restorative material offers superficial smoothness, cervical adaptation and physiologic wear compatibility with surrounding tooth structure.[2,19,24-2,23,14]
- Biological restorations not only mimic the missing part of the oral structures, but are also bio-functional. The clinical chair time for fragment bonding procedures is relatively short as compare to other restorative material, which is essential in pediatric patients.

- These restoration are very less subjected to extrinsic pigmentation and plaque accumulation as compared to composite resin.[14]
- Biological restoration helps in preserving the internal dentin wall of the root canal and offers excellent adhesion to the tooth structure and composite resin.[2]

Grewal N and Seth R in 2008 did an in vivo study on comparative evaluation of restoring severely mutilated primary anterior teeth with biological post and crown preparation and reinforced composite restoration and concluded that the biological preparation presented as a cost effective, clinically friendly, less technique sensitive and esthetic alternative to commercially available restorative materials used for restoring deciduous teeth affected by ECC.[9]

Wadhwani KK et al in 2013 studied the biological restoration as an option of reincarnation for severely mutilated teeth and concluded that biological restoration seems not to promote dentin stress, preserve the internal dentin wall of root canal, biocompatible and adapts to conduct configuration, favoring greater tooth strength and retention as compared to pre-manufacturing posts. It presents resilience comparable to original tooth, and offers an excellent adhesion to tooth structure and composite resin at low cost.[5]

**Disadvantages**

- It is very difficult to obtain teeth with the required coronal dimensions seperately to re-establish normal mesio-distal dimension for maintenance of proper arch length because the idea of availability of tooth from tooth bank is not widespread.[2,18,14,18]
- It is difficult to match fragment color with tooth color. Also, the fragment obtained from other's mouth is not a pleasant idea for some patients and many of them refuse to receive this treatment.[2,18,17,1,14]
- Availability of tooth from tooth bank is difficult (K Sanches et al, 2007)[18]
- Dehydration of the fragment occurs due to prolonged handling. It can also negatively affect its adherence to the bonding agent. In some cases reattachment may lead to visible of demarcation on tooth surface.[2,15,31]
- Excessive masticatory force may cause loosing of reattached fragment from the original tooth to the reattached tooth.[24]

Shirani F et al in 2012 studied the hydration and dehydration periods of crown fragments and concluded that specimens dried for a longer period appeared to lose their adaptability more than the specimens with shorter drying periods.[25]

**Conclusion**

Main objective of contemporary daily dentistry is "Preservation of what is natural". Based on the positive results of biological restorations it can be said that by using this knowledge, clinical experience, and judgment, the clinician can integrate the reattachment procedure into his or her practice to provide the contemporary dental patient with a viable treatment alternative.

**References**

1. Mathur S, Chopra R, Pandit IK, Srivastava N, Gugnani N. Biological Restoration of a Grossly Decayed Deciduous Mandibular Molar. In a severely damaged primary molar. Journal of clinical and diagnostic research. 2012; 6(1): 139-141.
2. Corrêa-faria P, Alcantara CEP, Caldas-Diniz MV, Botelho AM, Tavano KTA. "Biological Restoration": root canal and coronal reconstruction. 2010; 22(3): 168-176.
3. Shirani F, Malekipour MR, Manesh VS, Aghaei F. Hydration and dehydration periods of crown

fragments prior to reattachment. Operative dentistry. 2012; 37(5): 501-508.

4. Bariker RH, Mandroli PS, Gokhle N, Pujar P. Esthetic and functional restoration in a child with S-ECC using contemporary and biological techniques. Indian J dent adv. 2014; 6(3): 1649-1654.
5. Wadhwni KK, Hasija M, Meena B, Wadwa D, Yadav R. Biological restorations: option of reincarnation fo r severely mutilated teeth. European journal of dentistry. 2013; 2(1): 62-66.
6. Das UK, Maiti N. Nature's own alternative – restoration with biological crowns. Pediatric dentistry. 2013; 3(2): 144-149.
7. Dabas A, Dabas N, Prabhakar M, Sidhu MS. Regenerative dentistry: a journey from stem cell to a bio tooth. 2013; 5(3): 84-87.
8. Terry DA. Adhesive reattachment of a tooth fragment: the biological restoration. Prac proced aesthet dent. 2003; 15(5): 403-409.
9. Grewal N, Seth R. Comparative in vivo evaluation of restoring severely mutilated primary anterior teeth with biological post and crown preparation and reinforced composite restoration. JISSPD. 2008: 142-148.
10. Botelho AM, Tavano KTA, Correa-Faria P, Morato LNS, Viana MR. Esthetic–functional recovery of permanent posterior tooth using autogenous biological restoration. JISPPD. 2012; 4: 333-336.
11. Mandroli PS. Biological restoration of primary anterior teeth: a case report. JISPPD. 2003; 21(3): 95-97.
12. John SA, Anandraj S, George S. Biological restoration of a traumatized maxillary central incisor in a toddler: a case report. JISPPD. 2014; 32(1): 79-82.
13. Kavitha M, Gokul K, Raj A, Vino. Successful Esthetic Management of Discolored Tooth with Biological Veneer: A Case Report. Indian journal of multidisciplinary dentistry. 2013; 3(4): 832-835.
14. Indira MD, Dhull KS, B Nandlal, Kumar PSP, Dhull RS. Biological restoration in pediatric dentistry: a brief insight. International journal of clinical pediatric dentistry. 2014; 7(3): 197-201.
15. Osathanon T. Transplantation of cryopreserved teeth: a systematic review. Int J oral sci. 2010; 2(2): 59-65.
16. Goenka P, Marwah N, Dutta S. Biological approach for management of anterior tooth trauma: triple case report. JISPPD. 2010; 28(3): 223-229.
17. Grover R, Mehra M, Gupta S, Sadana G. Biological restoration: a simplified technique for the restoration of severely decayed primary anterior teeth. 2012; 2(1): 188-191.
18. Sanches K, Carvalho FK, Nelson-Filho P, Assed S, Silva FWGP, Queiroz AM. Biological restoration as a treatment option for primary molars with extensive coronal destruction- report of two cases. Brazil dent J. 2007; 18(3): 248-252.
19. Centers for disease control and prevention. Centers for disease control and prevention. Guidelines for disinfection and sterilization in healthcare facilities. U.S. Atlanta. 2008; 36-37.
20. Penmetcha S, Arali V. Cryopreservation of teeth: Freeze them now to use later. Dentistry's section.
21. Vaz VTP, Presoto CD, Paleari AG, Mandarino F, Minto AMP, Junior OBO, Andrade MF. Biological restoration: Asolution for restoring

teeth with coronal fractures in young patients. Scientific journal of dentistry. 2015; 2: 37-41.

22. Kumar M. Esthetic rehabilitation using natural teeth- case reports. J. int oral health. 2011; 3(5): 75-80.
23. Mishra N, Narang I. Bio-reconstruction of root canal using dentin post. Saudi endodontic journal. 2013; 3(2): 87-89.
24. Single S, Agarwal N, Shashikiran ND. Immediate management of complicated crown fracture: A case series. SRM journal of research in dental sciences. 2015; 6(3): 194-197.
25. Shirani F, Malekipour MR, Manesh VS, Aghaei F. Hydration and dehydration periods of crown fragments prior to reattachment. Operative dentistry. 2012; 37(5): 501-508.