Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Ensuring Viability: The Role of Storage Media for Avulsed Teeth

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Trauma, whether physical or psychological, is a major global health concern, responsible for millions of deaths and injuries each year. It encompasses both physical injuries, like blunt force or penetrating trauma, and emotional wounds resulting from stressful or life-threatening situations. Recognizing trauma's dual nature underscores the need for comprehensive approaches to care, combining medical interventions for physical injuries with psychological support for emotional well-being. The term "Trauma" originates from the Greek word for "Wound" and was first used around 1693. It refers to an injury, whether physical or psychological, caused by external factors or internal distress. This definition encompasses wounds to living tissue as well as the emotional and mental distress resulting from stress or injury. It disrupts tissue continuity and triggers a healing process to restore function. While wound healing processes are generally similar across tissues, outcomes vary.1 Traumatic dental injuries often affect the periodontium, pulp, and surrounding soft tissues. Most wounds, including those from trauma or surgery, heal with fibrous scar tissue, but oral mucosa scars less. Dental tissues have significant regenerative capacity, with structures like dentin, cementum, bone, and gingiva capable of partial regeneration. Pulp and periodontal ligament injuries may regenerate or heal with scar tissue or bone formation. Dental trauma is classified based on the injury's extent and location.

Keywords: global health, Teeth.

1. Introduction

Trauma, whether physical or psychological, is a major global health concern, responsible for millions of deaths and injuries each year. It encompasses both physical injuries, like blunt

force or penetrating trauma, and emotional wounds resulting from stressful or life-threatening situations. Recognizing trauma's dual nature underscores the need for comprehensive approaches to care, combining medical interventions for physical injuries with psychological support for emotional well-being.[1]

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Here are the main classifications:

1. Crown Fractures: These involve fractures that are confined to the enamel and/or dentin of the crown of the tooth. Crown fractures can vary in severity from minor enamel chips to more extensive fractures that involve dentin and possibly pulp.

2. Crown-Root Fractures: These fractures extend from the crown of the tooth through the enamel, dentin, and into the root of the tooth. They involve both the crown and the root portions of the tooth.

3. Root Fractures: These fractures occur within the root of the tooth below the gum line. Root fractures can vary in location and severity, affecting one or more roots of a multi-rooted tooth.[1]

Tooth avulsion, where a complete displacement from socket, is a severe dental trauma often seen in young children engaged in activities like sports.[3] Immediate emergency treatment, ideally replantation of the tooth to preserve periodontal ligament (PDL) viability, is crucial but not always feasible as conditions like the patient's consciousness and knowledge of first aid. A child of 7–10 year age group is particularly vulnerable to tooth avulsion due to their active participation in sports and playful activities involving direct body contact.[4] Avulsions account for a range of 1% to 16% of all dental injuries, highlighting their significant prevalence in dental trauma cases.[5] This age-specific risk underscores the importance of preventive measures and prompt management protocols to minimize the impact of such injuries on children's dental health and well-being.[4] The period from avulsion to replantation, known as the extra-alveolar time, is critical as the PDL tissues can dehydrate, risking the vitality of the tooth.[1] To mitigate this, interim transport or storage media are used to maintain PDL cell viability until professional dental care can be administered.[6] Tooth avulsion not only impacts dental health but also carries emotional significance, making timely and informed management essential to minimize long-term consequences.[4]

Choosing the right storage medium for an avulsed tooth is crucial for preserving the periodontal ligament (PDL) cells and ensuring successful replantation. The ideal medium

should mimic the oral environment in osmolarity and pH, be non-toxic, and not provoke allergic reactions. It should also have anti-inflammatory, antimicrobial, and antioxidant properties to protect the tooth during the extra-alveolar period.[7] Traditional options include:

- Hank's Balanced Salt Solution (HBSS): The gold standard for its optimal conditions.
- Patient's Own Saliva: If the patient is conscious, it helps keep the tooth moist.
- Milk: Readily available and effective due to its pH and nutrient content.

Research continues into natural products and new solutions to find a universally ideal medium that balances preservation efficacy with practical aspects like availability and cost.[7]

2. STORAGE MEDIA

A physiological solution which helps preserve the viability of PDL cells of avulsed tooth and is analogous to oral environment.[6]

Ideal properties of storage media

An ideal storage medium for an avulsed tooth should possess several critical properties to ensure successful replantation. Antimicrobial characteristics to prevent infection and maintain the viability for an acceptable period of periodontal fibers The solution should support the proliferative capacity of cells and hence enchance their growth and division, with osmolarity comparable to body fluids (290-300 mosmol/kg) and pH (7.2-7.4). The solution should most importantly be non-reactive with body fluids and not provoke antigen-antibody reactions. A good shelf life is essential, as is effectiveness in various climates and conditions.Additionally, complications such as root resorption or ankylosis post-replantation should be minimal. Lastly, extraneous materials and toxic waste products should be washed away effectively along with reconstitution of depleted cellular metabolites.[8]

Classification of Storage Media

1. Laboratory Prepared: Hank's Balanced Salt Solution, ViaSpan, Custodiol, Dulbecco's storage, Tooth rescue box, Conditioned medium, Gatorade, Growth factors, Ascorbic acid, Cryoprotective agents, Catalase supplementation, , Oral rehydration salt solution, GC Tooth Mousse, L – DOPA, Autologus serum, Contact lens solution, Eagle's medium.

2. Natural: Saliva, Pasteurized milk, Coconut water, Emdogain, Morusruba, Salvia officinalis, Green Tea Extract, Propolis, Honey milk, Soy milk, Tap water, Aloevera Extract, Pomegranate, Curcuma extract, Egg white, Neem Extract.

Laboratory Prepared

Hanks Balanced Salt Solution:

The HBSS is one of the widely used sterile solutions in biomedical research as it is a physiologically balanced isotonic standard salt solution which supports the growth of many cell types. Due to its ability of long-term preservation of PDL cell viability the American Association of Endodontists recommends the use of HBSS for avulsed teeth as the storage medium of choice. It is considered a gold standard to store and transport an avulsed tooth; it

is used to compare the efficacy of other storage media. HBSS was first formulated by the microbiologist John Hanks a microbiologist in the year 1940. It contains8 g/L sodium chloride, 0.4 g/L potassium chloride,, 0.14 g/L calcium chloride,0.4 g/L of D – glucose, 0.35 g/L sodium bicarbonate, 0.09 g/L sodium phosphate, 0.14 g/L potassium phosphate, 0.1 g/L magnesium chloride, and 0.1 g/L magnesium sulphate. These ingredients are vital to sustain and reconstitute the cellular components of the PDL cells.[7]

Normal Saline:

Normal saline is compatible with PDL cells. Employed for short period of time, it is not considered an adequate medium.[8]

Composition: Saline (also known as saline solution) is a commonly used mixture of sodium chloride (salt) and water. It is usually used as a sterile 9 g of salt per litre (0.9%) solution, known as normal saline. Normal Saline is a solution of 0.90% w/v of NaCl and osmolality of 280 mOsm/kg.

Viaspan:

An very effective storage media for avulsed teeth is ViaSpan, a cold transplant organ storage medium. Viaspan is the trademark of the University of Wisconsin cold storage solution. Designed as the first solution for use in organ transplantation, UW solution became the first intracellular -like preservation medium. Folkert Belzer and James Southard developed it in the late 1980s for pancreas preservation.[9] It has an osmolality of 320 mOsm/kg and its pH is around 7.4 at room temperature.

Composition: Hydroxy ethyl starch (Pentafraction), Lactobionic acid (as Lactone), Magnesium sulfate heptahydrate,Potassium dihydrogen phosphate, Potassium hydroxide 56%, Raffinose pentahydrate, Total Glutathione, Adenosine, Allopurinol, Sodium hydroxide/Hydrochloric acid (adjust to pH 7.4), Water for injection q.s.

Eagle's medium:

A synthetic cell culture medium used to maintain cells in tissue culture. Addition of vitamins, amino acids, and/or other nutrients has lead to development of many variations of this medium. It was developed by Harry Eagle in the year 1959.[10]

Composition: Eagle's minimal essential medium contains 4 mL of L-glutamine, 10^5 IU/L of penicillin, 100 μg/mL of streptomycin, 10 μg/mL of nystatin and calf serum (10% v/v).

Custodiol:

Custodiol is a histidine-tryptophan ketoglutarate (HTK) solution with high flow properties and low potassium content. It is used as a preservation solution for organ transplantation. The physiological pH (7.02) and osmolality of this solution are known to facilitate cell proliferation and cell membrane stabilization.[11] It has an osmolality of 310 mOsmol/Kg.[11] It was introduced by Bretschneider in the year 1970.

Composition: Na+ (15 mmo/L), K+ (9 mmol/L), Mg^{2+} (4 mmol/L), Ca^{2+} (0.015 mmol/L), Histidine (198 mmol/L), Tryptophan (2 mmol/L), Ketoglutarate (1 mmol/L), Mannitol (30 mmol/L).

Dulbecco's solution:

It is Dulbecco's Modified Eagle's Medium (DMEM). Commonly used to store an avulsed tooth. It has physiologic pH. It maintains intracellular/extracellular osmotic balance. It provided nutrients (mainly glucose) for survival of cells.[12] It was introduced by Dulbecco and Vogt in the year 1959. Inorganic salts like Calcium chloride dehydrate, Potassium chloride, Ferric nitrate nonahydrate, Sodium chloride, Magnesium sulphate anhydrous and Amino acids like Glycine, L-Cystine dihydrochloride, L-Arginine hydrochloride, L-Glutamine, L-Isoleucine, L-Leucine, L-Lysine hydrochloride, L-Tryptophan, L-Methionine, L-Phenylalanine, L-Serine, L-Histidine hydrochloride monohydrate, L-Threonine, L-Tyrosine disodium salt, L-Valine and Vitamins like Choline chloride, Riboflavin,D-Ca-Pantothenate, Folic acid, Nicotinamide, Pyridoxal hydrochloride, Inositol, D-Glucose, Thiamine hydrochloride,Phenol red sodium salt.

Tooth rescue box:

Tooth rescue box was first developed in the year 1994. Examples of Tooth rescue boxes includes SOS Zahnbox®, Miradent Co., Hager & Werken GmbH Co., Duisburg, Germany; Dentosafe®, Medice GmbH Co., Iserlohn, German.[13]

Composition: Tooth rescue box is a culture medium containing salts, amino acids, glucose, vitamins, and other nutrients similar to the medium used during islet cell transplantation along with integrated pH-buffer.

Conditioned Medium:

Human gingival fibroblasts grown in culture are used to derive Conditioned Medium from the supernatant in the culture media. Stimulatory factors derived from the gingival fibroblast cells maybe present in the media and hence can have stimulatory effect on root surface cells.[11]

Composition: It contains nucleic acid, lipids, proteins, and trophic factors as chemokines, cytokines, hormones, growth factors, and extracellular vesicles. Array of growth factors are present including vascular endothelial growth factor (VEGF), epidermal growth factor, platelet-derived growth factor (PDGF), insulin-like growth factor I and II (IGF-I, IGF-II), fibroblast growth factor 2/basic fibroblast growth factor (FGF-2/bFGF), hepatocyte growth factor (HGF), keratinocyte growth factor/fibroblast growth factor-7 (KGF/FGF-7), heparin binding epidermal growth factor, platelet-derived endothelial cell growth factor, neural growth factor (NGF), and brain-derived neurotrophic factor (BDNF). Additionally, proinflammatory cytokines including IL-8/CXCL-8, IL-9, and IL-1β were found along with anti-inflammatory cytokines such as transforming growth factor- (TGF-) β1 and interleukins (IL), including IL-6, IL-10, IL-13,IL-17, andIL-27. Furthermore, granulocyte macrophage CSF (GM-CSF), granulocyte colony stimulating factor (GCSF), and prostaglandin E2 (PGE).[14]

Gatorade:

Gatorade a common oral rehydration fluid is commonly found at sporting events, is a potential transport medium. It is consumed as a snack by non-athletes, the beverage is non carbonated sport drink. It has a pH of 3 and osmolarity ranging from 280 to 360 mOsm/L.[8] First introduced in the year 1965 by a team of researchers at University of Florida, led by Robert Cade. The

sports drink contains water as the base in which sucrose (table sugar), dextrose, natural flavor, citric acid, sodium citrate, sodium chloride (table salt), monopotassium phosphate, and flavoring/coloring ingredients are added. Variations with brominated vegetable oil as a stabilizer have also been introduced in some flavours of the sports drink. Brominated vegetable oil has been replaced with sucrose acetate isobutyrate since 2013.

Contact lens solution:

Contact lens solutions are essentially saline solutionsthought to be of possible benefit as a storage solution. They are comprised of a cationic antimicrobial component and fatty acid monoester. The pH of contact lens solution is 7.4 +/- 0.1 and osmolarity is 310 mOsm/kg. Harry William Hind, a famed pharmacist, who innovated the contact lens solution. [15] It contains Disinfectants, surfactants, and preservatives like Boric acid, Alexidine dihydrochloride, EDTA, polyquaternium – 1, polyhexanide, and poly aminopropyl biguanide, myristamidopropyl dimethylamine, sulfobetaine, and sodium cirate. It also contains wetting agents and lubricants like Dextran, hyaluronic acid, hydroxypropyl guar, hydroxypropyl methyl cellulose, mineral oil, povidine, and sorbitol.[16]

Growth Factors:

The use of growth factors promote PDL regeneration and are used in storage media as they function as potent biological mediators. The growth factors were believed to be a protein as it is heat-labile, protease-sentitive, non-dialyzable and DNase- or RNase-insentitive.[17]

Ascorbic Acid:

Production of Type I collagen by osteoblasts is promoted by Ascorbic acid. It also promotes expressing specific markers associated with osteoblastic phenotypes such as alkaline phosphates (ALP) and osteocalcin.[18]

L-DOPA:

Levo DOPA is drug with possible mitogenic effect. It aids in healing process by secretion of growth hormone from the pituitary gland.

A Polish biochemist, Casimir Funk first synthesized L-DOPA in 1911. Marcus Guggenheimisolated the pure enantiomer L-DOPA in 1913 from the exotic bean plant Vicia faba. [19]

Cryoprptective agents:

Many studies have been done on success of reimplantation in low-temperature storage. James Lovelock, one of the early theoretician of cryopreservation in 1953, suggested osmotic stress was the main cause of damage to red blood cells during freezing.[20]

Schwart and Andreasen studied the cryopreserving agents, 10% glycerol, 5% and 10% dimethyl sulfoxide effects on PDL. They observed controlled freezing rates combined with use of different cryoprotectives, can preserve the PDL of reimplanted teeth.[21]

Catalase supplements:

Catalase is a common enzyme which catalyzes the decomposition of hydrogen peroxide to water and oxygen and is found in nearly all living organisms. It is a very important enzyme in

protecting the cell from oxidative damage.

Louis Jacques Thénard first noticed catalase in 1818.[22]

Composition:

It consists of essential nutrients which help in maintaining cell metabolism like glucose and vital salts. It also consists of potassium chloride, sodium citrate, sodium chloride, and extruded rice.

GC Tooth Mousse:

An innovative study of Reynolds et al led to the introduction of GC tooth mousse in late 2002. Tooth Mousse has a myriad of uses as a topical coating for teeth and has quickly become a firm favourite with dental professionals.[23] It is used to neutralise an acidic oral environment and additionally provide protection for teeth. Tooth Mousse has found many uses in dentistry including immediately following bleaching, after removal of orthodontic brackets, after ultrasonic and hand scaling, after application of topical fluoride and as a topical coating for patients suffering from caries, erosion, abrasions and conditions arising from xerostomia.[24] Tooth Mousse® (MI Paste®) and Tooth Mousse Plus® (MI Paste Plus®) contain 10% casein phosphopeptide– amorphous calcium phosphate (CPP-ACP) without or with 0.2% NaF, respectively (produced by GC, Tokyo, Japan). Tooth Mousse Plus® contains 900 parts per million fuoride in a molar ratio with the calcium and phosphate of 5 calcium, 3 phosphate and 1 fuoride.[23]

Autologus Serum

Autologous serum is used to treat a myriad of ocular surface diseases. It is a blood-derived eye drop that was introduced in the year 1975 by Ralph. The composition resembles that of tears; with the exception that it has more transforming growth factor-β (TGF-β),vitamin A, lysozyme, and fibronectin, and less epithelial growth factor (EGF),immunoglobulin A (IgA), and vitamin C than in tears.[25]

3. NATURAL STORAGE MEDIA

Pasteurized Milk: It is having physiological properties including pH (6.5-7.2) and osmolality (270 mOsm/kg) make it significantly better as they are compatible to the cells from the PDL; being the second or third best transportation media due to the osmolality, milk has been widely recommended for storing avulsed teeth.[8]

Saliva: Saliva used as an interim storage medium as it is composed of organic and inorganic components, and water. Organic components include: Proteins, citrate, lactate,amino acids, enzymes like amylase, lipase, and lysozyme, glucose, IgA, IgG, urea, uric acid, creatinine, cholesterol, and cAMP. Inorganic components includes: Sodium, potassium, phosphate, chloride, floride, and thiocynate.[26] It is one of the readily available storage medium at all the accident sites.

Propolis:

Propolis is found in bee hives, is a natural wax-like resinous substance used by the bees against

pathogenic microorganisms as a "chemical weapon". Propolis is a mixture of bee secretions and plant resins.[27] Propolis is a sticky resin that seeps from the buds or bark of trees, chiefly conifers. It consists of resin (rich in flavonoids) (45–55%), waxes and fatty acids (23–35%), essential oils (10%), pollen proteins (5%), and other organic compounds and minerals like magnesium, nickel, calcium, iron, and zinc.[8] Propolis has antifungal, antiseptic, antibiotic, antibacterial, antiviral, anti carcinogenic, antioxidant, antithrombotic, and immune-modulatory properties.

Coconut Water: It is liquid endosperm of coconut; rich in minerals, proteins, vitamins, and amino acids. This isotonic fluid is used to replace fluids, electrolytes and sugar lost from the body, available directly from the coconut or in packages and plastic bottles with long shelf life in many tropical countries. pH of the coconut water varies between 4.8 to 5.7. Coconut water can be used as a potential interim storage medium due to its high osmolality, composition, and ready acceptance by the human body.[28]

Egg White:

Egg white or egg albumin have high protein content with minimal microbial contamination and hence are considered a good choice. It has a pH of 8.6 to 9.3 and its osmolality is 258 mOsmol/kg. It is easily available and consists of water, vitamins, protein, fat, cholesterol, selenium, and choline.

Emdogain:

Emdogain is a mixture of enamel matrix derivatives (EMDs) used primarily for bone augmentation/regeneration treatments as they are an osteopromotive agent. Numerous studies have been done to showcase Emdogain abilities to enhance the osteogenic potential of bone marrow by enhancing the proliferation of osteoblasts,increasing the total number of stromal cells, stimulating migration, promoting cell differentiation,and viability of osteoblasts, leading to improved bone regeneration. Emdogain® consists of amelogenins as it is derived from a purified acidic extract from the enamel matrix protein of the tooth bud.[29]

Salvia Officinalis:

Salvia, the largest genus of Lamiaceae, has been credited with numerous medicinal uses and is wide spread all over the world,including approximately 900 species. Salvia officinalis (S. officinalis) extracts. The main compounds of Salvia Officinalis were as follows: (E)-β-caryophyllene, thujone, 1,8-α cineole, α-humulene, β-pinene, allo-aromadendrene, β-thujone, camphor, borneol, and α-pinene. It also contains phenolic contents as rosmarinic acid, carnosic acid, salvianolic acid,carnosic acid,and its derivatives rosmadial, carnosol, epirosmanol, rosmanol, and methyl carnosate.[27]

Green Tea Extract:

Green tea (GT), a widely consumed beverage rich in catechin,which is one of the polyphenols. It is extracted from Camellia sinensis. Catechins in GT are catechin, epicatechin, epigallocatechin, epicatechin gallate, epigallocatechin-3-gallate (EGCG), and so forth.[11]

Honey Milk:

Studies on natural unheated honey have shown its broad-spectrum antibacterial activity on

testing against food spoilage bacteria, pathogenic bacteria and oral bacteria. It is an effective transport and storage media for avulsed tooth due to its long-shelf life as HBSS. Some of the ingredients of honey milk are; 11gm carbohydrate, minimally 8% non-fat solid milk, 3gm protein, 0.6gm minerals, 0.1gm calcium and 0.12gm phosphorous and natural honey (5%).

Soy Milk:

High-quality protein and amino acid water extract of soybean, is called soy milk. It contains very small amounts of saturated fatty acid and no cholesterol or lactose. It is an excellent culture media for biochemical activities and cell growth. Studies have shown potential role of Soy milk in the prevention of chronic diseases such as osteoporosis, menopausal disorders, atherosclerosis and even cancer. It contains 2.86% protein, 1.53% fat, 0.27% ash, 1.53% carbohydrate, 93.81% moisture, and about 3 ppm riboflavin.[30]

Tap water:

Tap water may be used for very brief periods as storage medium as it may lead to ankylosis and replacement resorption. It is used to only to prevent dehydrationfor when there are no alternatives available .Tap water has a pH of 7.4 to 7.79 and an osmolality of 30 mOsm/kg. Tap water might contain minerals like Iron, fluoride, arsenic, nitrate, chloride, magnesium, calcium, radium, lead, and so on.[8]

Aloe Vera Extract:

Aloe Vera plant is a member of Liliaceae family. Popular in herbal medicine this medicinal plant is filled with a transparent viscous gel and has cactus like with green, tapered leaves. It has a pH of 5.21 to 7.14 and osmolality of 296 to 324 mosmol depending on concentration. This gelatinous substance of Aloe Vera contains mainly 96% water and 75 active properties such as vitamins, salicylic acids, enzymes, sugars, minerals, and amino acids.[31]

Pomegranate Juice

Pomegranate is the fruit of Punica granatum (Punicaceae). It has found many uses in folk medicine of many cultures. Acidosis, respiratory pathologies, dysentery, diarrhea, microbial infections, hemorrhage, and hypertension have used pomegranate fruit as part of the treatment in traditional medicine.It is a rich source of flavonoids principally anthocyanins.[32]

Curcuma Extract

Curcumin is known for its anti-inflammatory, antiseptic, antimicrobial, antimutagenic and antioxidant. Growth of various microorganisms is inhibited by antimicrobial effect of curcumin. It has a wide myriad of biologic actions as a natural medicament. It has a pH balance of 7.1 with an osmolality of 260 mosmol/kg. In the 19th century, curcumin was isolated from the primary colouring compound of turmeric. Turmeric's pale yellow to orange-yellow coloured volatile oil (4-6%) is composed of mono- and sesquiterpenes, including curcumenone. Ukon D, a polysaccharide comprises of L-arabinose, D-mannose, D-galactose, D-glucose. Turmerin, a water soluble peptide is composed of arginine, aspartic acid, glutamic acid, alanine, glycine, methionine, proline, tyrosine, leucine, isoleucine,serine, and phenylalanine and valine.[33]

Neem Extract

A common medicinal tree in India, known as Azadirachta indicais considered holy. Known for its wide spectrum of biological activity and as one of the most versatile medicinal plants since 2000 years. In Sanskrit, it is called “arishtha” meaning reliever of sickness and is regarded as the village dispensary of India.[34] It is biocompatible with pH balanced at 7–7.5 and has an osmolality of 270 mosmol/kg.[35]

4. CONCLUSION

Trauma to teeth can cause various injuries, such as avulsion of tooth out of its socket. This particular injury accounts for 0.5% to 16% of all traumatic injuries to permanent front teeth. Immediate replantation is ideal but may be delayed due to logistical challenges. Factors influencing successful replantation include age, root development stage, trauma severity, socket treatment, splinting, and timing. Choosing the right storage medium before replantation is crucial to prevent desiccation and preserve viability of periodontal ligament cell. Hank's Balanced Salt Solution (HBSS) and milk are recommended for their physiological properties. Milk, particularly endorsed by dental associations, is widely accessible and effective for storage of avulsed teeth temporarily. Research continues into new storage solutions like propolis and tender coconut water to further enhance treatment outcomes.[5]

References

1. Andreasen J.O, Andreasen F.M, Andersson, L. Textbook and Color Atlas of Traumatic Injuries to the Teeth. (5th ed.). USA: Munksgaars Publishing; 2019.
2. “Trauma.” Merriam-Webster.com Dictionary, Merriam-Webster, https://www.merriam-webster.com/dictionary/trauma.
3. Juneja P, Kulkarni S, Raje S. Prevalence of Traumatic Dental Injuries and their relation with predisposing factors among 8-15 years old school children of Indore city, India. Cluj Medical. 2018;91(3): 328-335.
4. Alotaibi S, Haftel A, Wagner N.D. Avulsed Tooth. (1st ed.). USA: StatPearls; 2021; 1(1).
5. Fouad A.F, Abbott P.V, Tsilingaridis G, Cohenca N, lauridsen E. International Association of Dental Traumatology Guidelines for the Management of Traumatic Dental Injuries: 2 Avulsion of Permanent Teeth. Dent Traumatol. 2020;36(1): 331-342.
6. Subramaniam P, girija P, Eswara U, Kadalagere L. Oral rehydration salt-liquid as a storage medium for avulsed tooth. Dent Traumatol. 2015;31(1): 62-66.
7. Poi W.H, Sonoda C.K, Martins C.M, Melo M.E, Pellizzer E.P. Storage Media For Avulsed Teeth : A Literature Review. Braz Dent J. 2013;24(5): 437-445.
8. Khinda V.S, Kaur G, Brar G.S, Kallar S, Khurana, H. Clinical and Practical Implications of Storage Media used for Tooth Avulsion. Int J Clin Pediatr Dent. 2017;10(2): 158-165.
9. Southard, J.H, Belzer, F.O. Organ Preservation. Annu Rev Med. 1995;46(1): 235-247.
10. Eagle H. Amino Acid Metabolism in Mammalian Cell Cultures. Science. 1959;130(1): 432-437.
11. Sangappa S.K, Kumar A.P, Shruti, Srivastava P. Extra-Alveolar Storage Media for teeth: A Literature review. Int J Adv Res. 2014;2(7): 963-972.
12. Gomes M.C.B, Westphalen V.P.D, Westphalen F.H, De nato U.X, Fariniuk L.F. Study of Storage Media for Avulsed Teeth. Braz Dent J. 2009;1(2): 69-76.
13. Lajtman A.Z, Connert T, Kuhl S, Filippi A. Cling film as storage medium for avulsed teeth.

Swiss Dent J. 2017;127(1): 954-959.
14. Moshy S.E, Radwan I.A, Rady D, Abbass M.M.S, A A. Dental Stem Cell-Derived Secretome/Conditioned Medium: The Future for Regenerative Therapeutic Applications. Stem Cells Int. 2020;1(1): 1-29.
15. Lum E, Perera I, Ho A. Osmolality and buffering agents in soft contact lens packaging solutions. Cont Lens Anterior Eye. 2004;27(1): 21-26.
16. Optix-now. What's in Contact Lens Cleaning Solutions and Eye Drops?. Vision care guide. Available from: https://www.optix-now.com/latest-news/helpful-tips/1725-cleaning-solution-ingredients.html [2020].
17. Awawdeh L, Haimour R.N, Al -jundi S.H, Al-qaoud K. Human periodontal fibroblasts viability stored in Custodiol ® , coconut water and propolis An ex vivo study. Dent Traumatol. 2018;34(4): 1-25.
18. Ishikawa S, Iwasaki K, Komaki M, Ishikawa I. Role of ascorbic acid in periodontal ligament cell differentiation. J Periodontol. 2004;75(5): 709-716.
19. Abbott A. Levodopa: the story so far. Nature. 2010;1(1): S6-S7.
20. Lovelock J.E. The Haemolysis of Human Red Blood-Cells by Freezing and Thawing. Biochim Biophys Acta. 1953;10(1): 414-426.
21. Poornima P, Kotari S, Sasalawad S.S, Nagaveni N.B, Roshan N.M. Save cells before tooth replantation: A review. Int j contemp dent med rev. 2015;1(1): 1-7.
22. Loew O. A New Enzyme of General Occurence in Organisms A Preliminary Note. Science. 1900;11(1): 701-702.
23. Schjott M, Andreasen J.O. Emdogain does not prevent progressive root resorption after replantation of avulsed teeth: a clinical study. Dent Traumatol. 2005;21(1): 46-50.
24. Bajaj A. Trade News – What's New. Br Dent J. 2020;8(1): 489-491.
25. Pan Q, Angelina A, Marrone M, Stark W.J, Akpek E.K. Autologous serum eye drops for dry eye. Cochrane Database Syst Rev. 2017;2(1): 1-52.
26. Kumar B, Kashyap N, Avinash A, Chevvuri R, Mylavarapu K.S. The composition, function and role of saliva in maintaining oral health: A review. Int j contemp dent med rev. 2017;1(1): 1-6.
27. Anegundi R.T, Daruwalla S.F. Assessment of Viability of Periodontal Ligament Cells in Different Storage Media. Int J Oral Health Med Res. 2016;3(1): 21-27.
28. Ali S.A, Al-jundi S, Mhaidat L, Awawdeh L, Naffa R. Effect of Coconut Water Concentration on Survival of Bench-Dried Periodontal Ligament Cells. Int J Clin Pediatr Dent. 2011;4(1): 9-13.
29. Gusiyska A, Gateva N, Peev S, Stnimirov P, Raychev I. Enamel Matrix Derivative (Emdogain®) in the Treatment of Late Replantation of an Avulsed Central Maxillary Incisor: A Case Report. Sylwan. 2016;160(2): 29-37.
30. Silva E.J.N.L, Rollemberg C.B, Coutinho-filho T.S, Krebs R.L, Zaia, A.A. Use of soymilk as a storage medium for avulsed teeth. Acta Odontol Scand. 2013;71(1): 1101–1104.
31. Fulzele P, Baliga S, Thosar N, Pradhan D. Evaluation of Aloevera Gel as a Storage Medium in Maintaining the Viability of Periodontal Ligament Cells - An in Vitro Study. Int J Clin Pediatr Dent. 2016;40(1): 49-52.
32. Hojjati S.T, Aliasghar E, Babaki F.A, Emadi F, Parsa M. Pomegranate Juice (Punica Granatum): A New Storage Medium for Avulsed Teeth. J Dent (Tehran). 2014;11(2): 225-232.
33. Niranjan A, Prakash D. Chemical constituents and biological activities of turmeric (Curcuma longa L) - A review. J Food Sci Technol. 2008;45(2): 109-116.
34. Hotwani K, Baliga S, Sharma K. Phytodentistry: use of medicinal plants. J Complement Integr Med. 2014;11(4): 233-251.
35. Mopagar V, Patil P, Padmawar N, Joshi S, Nara A. Comparative Assessment of Periodontal Ligament Cell Viability using three different Storage Media for Avulsed Teeth. Int J Sci Res. 2018;7(6): 37-40.