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Clinical and Practical Implications of Storage Media - First Aid for an Exarticulated Tooth

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Abstract

Background: Numerous materials have been researched for their use as potential storage media for avulsed teeth. The aim of this systematic review was to identify all these different storage Medias as well as to know the most recommended medium to store and transport avulsed teeth based on the survival of periodontal ligament cells as determined by the studies.

Methods: Laboratory-based experimental studies on PDL cells found on adult permanent teeth and literature reviews were included. Data were collected using PubMed/Google Scholar. The key terms employed were permutations of transport of avulsed permanent teeth, dental avulsion, biological transport, PDL cell viability, PDL cell survival, storage media or transport media.

Results: Milk was the most recommended individual medium followed by Hank's balanced salt solution. Among natural products other than milk, propolis, pomegranate juice, turmeric, aloe vera, neem, soy milk were some of the other media that have shown to have the required physiological characteristics like osmolality and pH.

Conclusion: Taking together the characteristics, efficacy and availability and accessibility, milk appears to be the most recommended storage media for avulsed tooth. Though not most frequently recommended, apart from milk, it is seen that natural products are more effective in maintaining the PDL cell viability compared to synthetic products.

Keywords: Tooth avulsion; Transport media; Storage media; Periodontal ligament cell viability; Osmolality; pH.

Introduction

Facial and dental trauma results in fracture, displacement or loss of tooth/ teeth. Tooth loss is called as avulsion or exarticulation is the complete out of tooth from its alveolar socket. This kind of dental trauma results in the early loss of teeth and have significant negative impact on function, esthetic, and psychology of children. The dental trauma to the primary teeth most commonly occurs at 2 to 3 years of age, when motor coordination is developing as. In permanent teeth the dental trauma occurs most often in the age group of 7-10 years, when the alveolar bone is resilient and offers minimal resistance to forces [1]. Avulsion of permanent tooth is the most serious as well as most common traumatic tooth injuries of all types because of the complete dislodgement of the tooth from its socket causing severe damage to the tooth supporting tissues, vascular and nerve structures[2].Prevalence of this type of injuries is between 1% and 16% involving the permanent dentition among all the type of tooth injuries [3].Avulsion represent one among the foremost common reasons for emergency appointments and survival of traumatized teeth is one of the main responsibilities of dentists. The prognosis of a replanted tooth depends on the viability of the periodontal ligament [PDL] cells remaining on root surface, integrity of root cementum and bacterial contamination which are the conditions directly related to the extra-alveolar time, type of storage medium after avulsion and root surface alterations. Andresen reported in his retrospective study that 90% of avulsed teeth could be successfully retained when they were replanted within the first thirty minutes of the accident[4].Immediate replantation of avulsed tooth into its socket is that the ideal treatment. Practically it is impossible to get immediate replantation done, so it needs to be transported in a suitable storage medium to dental office for treatment. A variety of storage media have been advocated for transporting avulsed teeth. This present article summarizes, in brief the role of readily and easily accessible storage media for an avulsed tooth to help in periodontal healing, its on-going developments, benefits, cost-effectiveness, shelf life and easy usage in this field milieu.

Why Do We Need To Know It?

Every trauma case is different in itself. No one case is similar to another and similarly requires different approach to treat and handle the situation. The very first step with respect to avulsion would require saving the tooth for further replantation. To save the tooth, it requires to keep the PDL cells viable till the tooth is replanted which is one of the critical step and a deal breaker in the prognosis of the tooth. To achieve this, we need a storage medium for the avulsed tooth in which the PDL cells can be kept viable. Hence, knowing about the tooth storage media which would prove to be of a great deal is essential not only for the dentist who treat the trauma but also anybody and everybody who could possibly be in and around such situations[5].The storage media for an avulsed tooth should have ideal characteristics. Hence, need for the accessible, easily available and affordable storage media is in the search. This article focuses on presently available and natural products used as a storage media for avulsed teeth which is easily accessible, Table 1 [5-8]. Blomlöf et al suggested ideal requirement for storage media as 290–330 μOsm/L and 6.6–7.8 pH, Table2 [9]. And medium also has to fulfil basically two requirements. First, it should provide the best possible conditions for the cells in the PDL to survive. Second, it's to be available at the time of need. Hence these factors will have a major role in determining the overall efficacy of a transport medium

while transporting the avulsed tooth to dental office, and thus it becomes mandatory while selecting the suitable transport media [10].

Saliva

The patients own saliva is the most easily and readily available transport media at the site of injury. The osmolality of saliva is 60-70 mOsm/kg and is much lower than the physiologic. The studies indicate that saliva may not be the most suitable medium for greater than 1 hour storage for avulsed teeth as its lower osmolality, non-physiological pH, its hypotonicity and also due to the potentially harmful substances such as enzymes, high microbial contamination and their by-product[11].However, saliva storage produces one-third less cell damage than dry storage or tap water. Thus, saliva can be considered to be an acceptable short-term storage medium and its use should be limited to cases where the extra-alveolar duration is less or other better storage media are not available [12].

Tap Water

Tap water is water that is safe to drink or use for food preparation and easily available. The tap water has a pH of 7.4 to 7.79 and an osmolality of 30 mOsm/kg which makes it a poor storage media .Tap water has characteristics like bacterial contamination, hypotonicity,non physiological pH, and osmolality which favors the PDL cell lysis and also reported to cause replacement resorption in avulsed teeth when they are placed in it.Blomlof reported that water is damaging to PDL cells hence it is not a good storage medium at any time. In view of this, tap water should be used only to avoid tooth dehydration[13].

Saline Solution

Normal saline is an isotonic solution of 0.90% w/v of NaCl, osmolality of 280 mOsm/kg and having pH 7.0 at 25 degree centigrade which is far lower than that of the body. Moreira-Neto et al and Pileggi et al evaluated the viability of cultured cells and recommended saline can to be suitable for short-term storage for about 2-3 hours, however, it is potentially damaging if the cells are stored for longer than this time period causing swelling and membrane harm in PDL cells, as well as the involvement of microorganisms. Hence, saline is not a good medium and can be indicated when other storage media are not immediately available at the site[14.15].

Oral Rehydration Solution [ORS]

ORS is another hypotonic storage medium whose compositions keep the optimal osmolality as well as pH and can even provide nutrients. The osmolality and pH of ORS is 270 mosm/L and 7.8 respectively which makes it suitable for cellular growth.According to studies ORS as storage medium found to be as efficient as HBSS and better than milk. Ricetral is a commercially available oral rehydration formulation with added vital salts which help in maintaining cell metabolism.In countries like Europe and Africa, ORS is recommended to have place in first aid kits as it is easily available and inexpensive [16].

Gatorade

Gatorade is non-carbonated hypertonic liquid widely used as sports drink.It has a pH of 3 and osmolarity ranging from 280 to 360 mOsm/L[12]. Gatorade contains sodium, potassium, chlorine, phosphorous, and carbohydrate which may cause damage to the cells due to the low pH and hypertonicity. Because of the favourable osmolality and carbohydrate content, which provides an energy source for the PDL, it appears to be a suitable medium for the avulsed tooth. Harkacz et al concludes that Gatorade did show as an adequate storing medium for avulsed teeth due to its low pH and high osmolality [17]. Gatorade preserves more viable cells than

tap water but less than compared to all other transport media, both at room temperature and on ice [12].

Milk

Milk is a nutrient-rich liquid food produced by mammary glands of female mammals. It is the primary source of nutrition for young mammals, including breastfed human infants before they are able to digest solid food.Milk is essentially an emulsion of fat,protein, lactose, carbohydrate, minerals and vitamins. Milk has physiological pH 6.5-7.2 and osmolality 270 mOsm/kg. These physiologic properties make milk significantly better storage media than other Medias for avulsed tooth [18].Milk being a gland secretion, contains epithelial growth factor, which stimulates the proliferation and regeneration of epithelial cell rests of Malassez and activates the alveolar bone resorption. This will ultimately contribute to isolate the bone tissue from the tooth and decrease the likelihood of ankylosis inspite of offering no conditions for the restoration of cell morphology, nor scell differentiation or mitosis as it prevents cell death.Blomlof et al, Trope and Friedman recommend milk as an excellent storing solution for 6 hours, however, milk cannot revive the degenerated cells.At a cellular level, The milk is ranked equal to HBSS as a storage medium although it loses its effectiveness after 2 hours. Milk has been widely recommended by dentists and general population for storing avulsed teeth to be replanted,being the second or third best transportation media for avulsed teeth after ViaSpan and/or HBSS, according to the International Association of Dental Traumatology and American Academy of Pediatric Dentistry [15].

Pomegranate

Pomegranate is the medicinal fruit of Punica granatum and has been used extensively in ayurvedic medicine as well as in folk medicine of many cultures. Pomegranate has antioxidant, anti-inflammatory, anti-carcinogenic properties and helps in fibroblast cell proliferation and cell attachment as it is a rich source of polyphenolic flavonoids. Tavassoli-Hojjati et al, reported that pomegranate is equally effective as HBSS and can preserve the spindle such as the morphology of periodontal fibers for 24 hrs after storage.The osmolality and pH is 280mOsml/L and 6.7 respectively[3,16].

Guava Leaves [Psidium guajaval]

Guava are tropic trees originating in central America.The guava leaves are used as a herbal tea and the leaf extract as a supplement. Guava is called the queen of fruits all because of its medical properties and capabilities, amazingly rich in antioxidants, vitamin A & C, potassium and fibers. A study carried out by Rajesh et al., in 2016 showed an increase in the optical density from 1 hour to 3 hours and observed an increase in cell viability at 15 to 30 minutes and 1 to 3 hours time intervals suggesting that media might have a proliferative capacity[19].

Turmeric

Turmeric is a common spice flowering plant comes from the root of Curcuma longa of the ginger family. The plant is native of Indian subcontinent and Southeast Asia and are widely used in cooking.The proven properties of curcumin include anti-inflammatory, antioxidant, antimicrobial, antiseptic, antimutagenic and a strong antiseptic agent.The growth of various microorganisms are inhibited by antimicrobial effect of curcumin.It has a pH balance of 7.1 with an osmolality of 260 mOsm/kg.Study showed that the turmeric can be used as short term storage medium [20].

Red Mulberry Juice [Morus rubra]

People believe that natural deep-coloured fruits, especially black and red mulberry fruits are healthier for the human body.They are rich in flavonoids, alkaloids

and polysaccharides, all of them are very important for cell preservation. Because of these rich properties of mulberry, it is considered to be having good medicinal values. According to Ozan et al., 4.0% concentration of red mulberry juice is significantly better media than other[21].

Aloevera [Barbadensis]

Aloe vera is cactus like with green, tapered leaves that are filled with transparent viscous gel having medicinal values . Aloe vera gel is widely known to relieve sunburn and help heal wounds and potentially slowing the spread of breast cancer. The gelatinous substance contains 96% water and active properties like vitamins, minerals, enzymes, sugars, salicylic acid , amino acids, anti-inflammatory, antioxidant, antibacterial, antifungal and anti-carcinogenic activities.Aloe Vera juice used as transport media in the preservation of PDL up to 9 hours. According to Badakhsh et al., aloe vera 10%, 30% and 50% concentrations may be recommended as a suitable alternative storage media[22].

Coconut Water [Cocus nucifera L]

The coconut is naturally occurring biologically pure and sterile product, rich in proteins, minerals, vitamins and amino acids. It has been widely consumed to replace electrolytes, fluids and sugar loss from the body.As a result of its high osmolality, composition and ready acceptance by the human body with ease of availability, coconut water has been studied as a potential interim storage medium. Gopikrishna et al. found that coconut water was most effective and might be better alternative to HBSS or milk [24]. Coconut water is shown to have kept significantly more PDL viable compared to HBSS, Milk or Propolis. According to Ali S et al., full concentration mature coconut water was superior to 50% dilutions obtained from either young or mature coconuts[2].Moura et al., claimed that if the pH of coconut water is adjusted to 7.0 and can be used as storage media for upto 24 hours. This finding holds high relevance in clinical practice, where presence of life-threatening conditions like complex fractures of jaw can delay the replantation of tooth[24].

Egg White

Egg white is the albumin or the glair/glaire within an egg. Egg white is an alkaline solution and contains approximately 40 different proteins. This medium is considered a good choice for teeth undergoing delayed replantation due to its high content of proteins, vitamins,water and also absence of microbial contamination.When compared to milk, egg white as solutions for storage medium of avulsed teeth have shown that teeth stored in egg white up to 6 to 10 hours had better incidence of repair and lower surface resorption .The osmolality of egg white range between 251 to 298 mOsm/kg and pH is of 8.6 to 9.3.

Propolis

Propolis is a natural wax-like sticky dark brown or red resinous produced by honeybees in construction of their hives. Propolis is composed of flavonoids vegetable balsam, fatty acids ,wax, vitamins ,sugars and aromatic oils, pollen proteins , trace minerals and other organic substances.The main active ingredients of propolis are flavonoids[8,56] .Propolis has antioxidant, anti- inflammatory, antifungal, antimicrobial immune-modulatory, anti-ulcer, and antitumor properties. It is nontoxic and inhibits osteoclastic resorption of teeth. Ozan et al., suggested propolis is superior to HBSS or milk in maintaining PDL cell viability after storage of avulsed tooth and also said it can be considered as a favorable storing medium. Ideal period for maintaining avulsed tooth in Propolis is about 6 hours,which is beneficial for cell maintenance. It has been found that 10% propolis can be used to store

avulsed tooth for as long as 24 h. Hence propolis can be a promising storage media due to its medicinal values and long duration of storage time to maintain viable cells [6,13,25,26].

Green Tea Extract

Green tea extracts consist of catechin,epicatechin, epigallocatechin-3-gallate, epicatechin gallate and epigallocatechin. Green tea has remarkable anti-inflammatory, antioxidant and anticarcinogenic properties.The rich antioxidant is known to protect the alveolar bone resorption from periodontal diseases and the formation of osteoclasts. The study showed that Green tea is better storage medium than HBSS and milk, with less risk of root resorption and ankylosis. Hwang et al., and Jung et al., reported enthusiastic results with green tea extract, with the maintenance of 90% of cell viability for upto 24 hours , having 5.91 pH and 139 mOsml/kg osmolality[16,27].

Honey Milk

Honey milk is non-fat solid milk having nutrients like protein, carbohydrate, calcium, minerals, phosphorous ,amino acids , vitamins, minerals and natural honey,which help in nourishing the cells and maintaining their viability.Long-shelf life honey milk also considered as appropriate storage media which are like HBSS and better than fresh milk medium. In a study fresh milk revealed the best outcome after 1 hour. After 9 hours, long-shelf life honey milk showed better results in comparison to fresh milk[28].

Salvia Officinalis

Salvia officinalis is a perennial, evergreen shrub which features a long history of culinary and medicinal use.This extract has been proposed as a storage medium for avulsed teeth because of the anti-oxidants effects caused due to the presence of phenolic components and derivatives. Studies have shown that Salvia extract at 2.5% helps maintain PDL cells viability up to 24 hours in comparison with HBSS, PBS and Tap water. Thus salvia officinalis can be recommended as suitable storage media for avulsed teeth[16,28].

Neem [Azadirachta Indica]

Neem leaf and its constituents have been verified to exhibit immunomodulatory, anti-inflammatory, antihyperglycemic, antifungal, antiviral, antioxidant, antimutagenic, and anticarcinogenic properties. Neem is biocompatible with pH balanced at 7–7.5 and has an osmolality of 270 mosmol/kg[18].

Soya Milk

Soy consumption worldwide has been steadily growing, mainly due to it being considered a healthy food, but also for medical reasons.Soy milk has a high nutritional value and protein content. It has osmolality of 267 mOsm/kgand and pH of 7.3 ,can be used as tooth storage media for about 12-24 hours[29].

Contact Lens Solution

Contact lenses solutions are fatty acid mono ester composites with an antimicrobial cationic component. Sigalas et al suggested contact lens solutions weak in maintaining the viability of cultured PDL cells. Nonetheless, in the absence of another storage medium, they may be used for short periods of time.It has osmolality of 310 mOsm/kg and pH of7.8[30].

Rice Water

Due to nutritional value of rice especially in countries with intense consumption, rice water is studied as a storage medium for avulsed teeth .According to a study the viability of PDL cells compared with milk, the results showed that the maximum percentage of viable cells were found in rice water followed by egg white and least in milk at 30 minutes. This could be explained

by the very fact that it has low sodium content, potassium, vitamin B, thiamine and niacin[31].

Castor Oil

This vegetable oil has the capacity to repair bone defects.Mohammadreza evaluated and compares the capacity of castor oil with HBSS and milk. The percentage of viable cells treated with castor oil, HBSS, and milk counted immediately after removal from these media was 46.93%, 51.02 %and 55.10 % respectively hence it is poor media to preserve the viability of PDL cells efficiently[33].

Platelet Rich Fibrin

According to study done to compare the efficacy of PRF and HBSS, it was shown that both demonstrated a similar number of viable PDL cells and suggested that PRF can be used as a good storage media for avulsed teeth. According to Warunee et al., PRF releases growth factors rapidly after participation and its release continues slowly over a period of time.Since PRF is prepared from own blood without additives,ready availability and cost effective;it also matches the pH and osmolality of blood so it can be used as storage media[34].

Patient's Own Serum

Thonner advocated the use of the patient's serum as a storage medium and histological picture of the periodontium showed that the cementum and periodontal tissue present over the root are well vascularized with tooth stored in serum [35].

Dragon's Blood SAP [Croton Lechleri]

The dragon's blood sap also has been suggested as a promising medium because it supports collagen formation and exhibits healing.According to a study dragon's blood sap showed good results due to its considerable maintenance of cell viability when compared to milk[36].

Capparis Spinosa

Traditional therapeutic applications of Capparis spinosa have been reported in Ancient Romans as having various pharmacological activities.When compared with Dulbecco's Modified Eagle Medium,HBSS and light milk, Capparis spinosa showed the best result for cell viability. The study recommends that Capparis spinosa can be a suitable, alternative storage medium for avulsed teeth[37].

Lime Juice

According to study the human PDL cells showed 100% viability in lime juice and the study concluded that lime juice can be effectively used as storage media for maintaining PDL cells viability [38].

Black Tea

According to study the viability of PDL cells in black tea showed 98% viability and concluded that black tea can be used effectively as storage media for maintaining PDL cells viability[38].

Passion Fruit Concentrate

Studies conducted to assess the viability of PDL cells in passion fruit concentrate, it was observed that 100% viability and suggested passion fruit concentrate can be used effectively as storage media for maintaining PDL cells viability up to 1 hour[38] .

Ocimum Sanctum /Tulsi

Tulsi has been found to be having antimicrobial, anti-inflammatory, analgesic, and antipyretic properties. Tulsi also attributed to its high content of phenolic compounds and phytochemicals like flavonoids, tannins, terpenoids, and saponins in the leaves and the stem which act as health promoting compound as a results of their anion radicals and have a high anti-oxidant and anti-fungal properties .As a storage medium

its efficiency seems to be on par with milk and could be a potential alternative to storage media with added advantage of omnipresence and easy availability[39].

Eagle's Media

Culture media can include Eagle's medium, Modified Eagle's medium & Dulbecco's storage medium. modified Eagle's medium (MEM) and Dulbecco's Eagle's medium contains many nutrients like amino acids, vitamins and bicarbonates considered essential for maintaining the viability and proliferative capacity of PDL cells The eagles medium at 37 °C is a recommended storage medium as it can preserve the PDL up to 8-24 hours. It has an osmolality of 310-360mOsm/kg and pH of 6.8 -7.2 [40].

HBSS

It is a standard saline solution that is non-toxic, biocompatible with PDL cells, pH is at 7.2 and an osmolarity of 320mOsm/kg. Ashkenazi et al. showed that HBSS was the most effective medium for preserving viability, mitogenicity, and clonogenic capacities of PDL cells for up to 24 hours at 4 °C. Due to its ability to preserve vitality and proliferative potential, HBSS is an exceptionally good medium for transportation of avulsed teeth. PDL's potential for a long period of time as up to 96 hours[55].HBSS is recommended as gold standard solution as storage media by the International Association of Dental Traumatology as a storage medium[6].

VIASPAN

ViaSpan is a medium used for the transportation of organs which are going to be transplanted and is an effective storage media for avulsed teeth as long as 144 hours. Its osmolarity is 320mosm/kg and pH of 7.4 which is ideal for cell growth[41].

L- DOPA

Drug that may have mitogenic properties and promotes healing. It causes the anterior section of the pituitary gland's dopaminergic systems to generate growth hormone, which is a stimulator of the healing process. L-dopa stimulates dopaminergic systems and also having osmolality and pH of 238 mOsm/kg and 2.3-8.11 respectively,hence be used as a tooth storage media for more than 1 hour[41].

Probiotic Solution

Recently a host probiotic, L. reuteri DSM 17938 and L. reuteri ATCC PTA 5289, have been shown to preserve vitality of PDL cells[28].

Growth Factors

Polypeptide growth factors, which are important biological mediators for wound healing, speed up the regeneration of PDL cells.Lynch et al demonstrated that short-term application of a combination of platelet-derived growth factor and insulin-like growth factor can enhance the formation of the periodontal attachment,hence supplementing growth elements in storage media boost the medium's effectiveness when the storage period is longer than 24 hours[42].

Ascorbic Acid

Studies suggest that addition of ascorbic acid may serve as a potential storage medium.As ascorbic acid stimulate type I collagen production considered to be an initial process in differentiation of PDL cells regeneration [28].

Custodial / Histidine- Tryptophan- Ketoglutarate [HTK] Solution

This medium is the registered trademark of Dr. Franz. It contains a histidine-tryptophan ketoglutarate solution containing high flow properties and low potassium content. According to a study done to check the use of HTK solution as a storage medium for avulsed

tooth, it was seen that the highest cell viability was observed in 50% HTK solution.According to Alaçam et al., it is available to the general public in the same way as other organ storage medium, and hence has limited value as a storage medium for avulsed teeth[43].

Dulbecco Storage Medium

It has vitamins, amino acids and minerals with pH about 6.87 and osmolality of 310 mOsml/kg . The studies show that it can be effectively used as storage media for avulsed tooth for about 30 minutes to 24 hours[44].

Antibiotics

Studies suggested that the Doxycycline/minocycline with saline solution are also a very good storage medium due to its PDL viability and antibacterial property[14].

Emdogain (Enamel Matrix Derivative)

Emdogain is a derivative of commercial enamel matrix extracted from the development of embryonic enamel originating from procine and contains several matrix proteins.Emdogain influences the migration, attachment, proliferative capacity and bio- synthetic activity of PDL cells**.** It is therefore a recommended therapeutic agent for storing avulsed for about an hour.It has pH of 4.5 and osmolality of 407mosm/kg[41].

Catalase Supplementation

Buttke and Trope observed that supplementation with catalase resulted in significant reduction of surface resorption. Hence addition of an antioxidant such as catalase can have beneficial effects on PDL cells[42].

Cryprotective Agents

Schwartz and Andreasen studied the effects of cryopreserving agents 5% and 10% dimethyl sulphoxide and 10% glycerol, on PDL. They observed that the use of different cryoprotectives, combined with controlled freezing rates to -196 degree celsius, can preserve the PDL of the replanted teeth to a greater extent[42].

Cornisol

Cornisol is a sterile, 20 ml buffered corneal preservation medium supplemented with chondroitin sulfate, recombinant human insulin,stabilized L-glutamine, Dextran ,vitamins, trace elements, gentamicin, streptomycin and pH indicator.A comparative ex vivo study conducted to check the survival of human PDL cells in cornisol and HBSS,concluded that cornisol can be used as a storage media and is significantly more effective than HBSS in maintaining the PDL cell viability[45].

HAM'S F-10

HAM'S F-10 contains a wider variety of components, including zinc, hypoxanthine, and thymidine. Maryam Talebi et al to assessed the viability and reproducibility of PDL cells stored in Ham's F-10 solution, it is seen that the viability of PDL cells stored in Ham's F-10 and HBSS was significantly greater than that of samples stored in milk and tap water at all-time . According to researcher the Ham's F-10 is capable of preserving PDL cells viable and reproducible better than milk and tap water and similar to HBSS hence HAM'S F-10 can used as storage medium for avulsed tooth[46].

Pedialyte

Pedialyte is a medical-grade hydration solution specially formulated with the optimal balance of sugar and electrolytes needed to help replenish vital fluids, nutrients, and minerals.Study by Sara Macway and Thomas to determine whether Pedialyte is a viable alternative storage solution for avulsed teeth by assessing its ability to preserve human PDL cell viability it is seen that Pedialyte at 4°C and 25°C showed significantly higher cell survival compared with water after all time intervals. No significant difference was

noted between MEM, HBSS, coconut water, and Pedialyte at 4°C after 2 hours.Thus Pedialyte is a viable alternative as a storage solution for avulsed teeth[47].

Conditioned Medium from Placenta- Derived Mesenchymal Stem Cells

Conditioned medium from placenta-derived mesenchymal stem cells (PMSC-CM) contains a variety of growth factors. According to a Ling-Li Ji et al PMSC-CM can be suggested as storage medium to maintain the cell viability of avulsed teeth as it was seen that the apoptosis rate of PDL cells were significantly lower than that of HBSS at 24 hours.Thus, PMSC-CM could be a promising storage medium for avulsed teeth[48].

Casein Phosphopeptide

Casein phosphopeptides [CPP] are derived from casein, which account for 80% of the total protein in bovine milk.They can form soluble organophosphate salts and may function as carriers for different minerals, especially calcium. Cehreli SB et al.,concludes in their study that the CPP can be used as storage medium for short time[4].

Euro Collins Solution

Euro-Collins solution was developed for the protection of organs for transplantation, whose characteristics have raised interest for its use as a storage medium for avulsed teeth to carry replantation. The study conducted to evaluate histologically and morphometrically the healing process of dog teeth replanted after storage in Euro-Collins solution or bovine milk. The findings of this study advocate that the Euro-Collins solution is an good enough storage medium for retaing avulsed teeth for up to eight hours before replantation[49].

Dentosafe

Dentosafe is the commercial name of a tooth rescue box containing special cell culture medium. It has demonstrated the maintenance of vitality of PDL cells for 48 hrs at room temperature. If unopened, this medium has a shelf-life of 3 years. A study by Pohl et al., showed functional healing and recommended that Dentosafe should be included in all first aid kits.The use of this system is self-explanatory and simple to understand for lay persons[9,28].

Clingfilm

The long-term prognosis of avulsed teeth primarily depends on the behavior at the scene of the accident. Anja Zeissler–Lajtman et.al., evaluated whether cling film facilitates the survival of PDL cells and concluded that cling film possibly could be used as an alternative transport medium for a storage period of up to 6 hours[50] .

Conclusions

Review of literature exhibited a wet extra-alveolar duration is frequently preferable to a dry one in terms of storing avulsed tooth when extra-alveolar time is more than five minutes after replantation, the best results are obtained. In comparison to synthetic products, natural products are more effective at preserving PDL cell viability. Milk is the most favored storage medium individually, based not only on PDL cell viability but also on practical considerations. Milk is good as HBSS for storing avulsed teeth for over to one hour, and it is superior to saline, saliva, or water. In case of emergency, it is important for dentists to consider the circumstances of the accident, the location and suggest an appropriate transport medium for the avulsed tooth to carry.There isn't a single product or solution that possesses all the characteristics needed to be indicated as the ideal storage medium for avulsed teeth, that is,be able of preserving the vitality of the PDL and pulp cells, while presenting compatible physiological pH and osmolality, clonogenic capacity, antioxidant property, no or minimal microbial contamination, high vacuity, ready accessibility at

accident spot like homes, schools, hospitals, playground and dental offices.

Table 1: Transport (Storage) medium should exhibit following characteristics of [5-8]

- ✓ It should maintain viability of periodontal fibers.
- ✓ It should preserve the functional capacities of periodontal ligament.
- ✓ It should be clonogenic and mitogenic capacity.
- ✓ It should have physiological osmolarity and pH.
- ✓ It should not have antigen antibody reactions.
- ✓ It should have less risk of root resorption.
- ✓ It should be effective under different conditions.
- ✓ It should have antimicrobial property.
- ✓ It should stimulate the dental alveolus.
- ✓ It should have antioxidant property.
- ✓ It should increase the osteoclastogenic potential of the PDL cells,
- ✓ It should have easy availability.
- ✓ It should be readily accessible at the site of trauma.
- ✓ It should be inexpensive.
- ✓ It should have low bacterial content.
- ✓ It should have essential nutrients.

Table 2: Exhibits Osmolality/ concentration, pH and duration of different transport media

Number	Media	Osmolality	pH	Duration
1	Saliva	60-70 mOsm/kg	6.2-7.6	Not more than 1hour
2	Water	30 mOsm/kg	7.4-7.79	Shorter duration
3	Saline	280 mOsm/litre	7.0	Up to 2–3 hours
4	O R S	270 mOsm/kg	7.8	Up to 12 hours
5	Gatorade	280–360 mOsm/kg	3	Shorter duration
6	Milk	270 mOsm/kg	6.5-7.2	Up to 6 hours
7	Pomegranate	280 mOsm/L	6.7	24 hours
9	Turmeric	260 mOsm/kg	7.1	Short term duration
8	Red mulberry juice	4%	-	12 hours
9	Aloe vera	280-300 mOsm/L	6.8	Up to 9 hours
11	Coconut Water	288 mOsm/kg	4.1- 7	24 hours
12	Egg white	251-298 mOsm/kg	8.6- 9.3	Up to 10 hours
13	Propolis	350 mOsm/L	7.4	24 hours
14	Eagle's madia	310-360mOsm/kg	6.8-7.2	8-24 hours
15	Green tea extract	139 mOsm/kg	5.91	24 hours

16	HBSS	320 mOsm/L	7.2	up to 48 hours
17	Viaspan	320 mOsm/kg	7.4	144 hours
18	L- dopa	238mOsm/kg	2.3-8.11	>1 hour
19	Growth factors	-	-	24 hours
20	Honey milk	-	-	Up to 6 months
21	Saliva officinalis	2.5%	-	12-24 hours
22	Dulbecco medium	310 mOsml/kg	6.87	30 minutes- 24 hours
23	Neem	270 mOsm/kg.	7-7.5	30 minutes
24	Soya milk	267 mOsm/kg	7.3	12-24 hours
25	Contact lens solution	310 mOsm/kg	7.8	More than1 hours
26	Rice water	-	-	30 minutes
27	Clingfilm	-	-	6 hours
28	Emdogain	407mOsml/kg	4.5	More than1 hours
29	Platelet rich fibrin	-	-	45 minutes
30	Dimethyl sulphoxide	5-10% 10%	-	-
31	Dragon's blood sap	10% (diluted with PBS)	-	24 hours
32	Caparis spinosa	-	-	26 hours
33	Cornisol	-	-	Up to 96 hours
34	Lime juice	0.625%	-	1 hour
35	Black tea	0.625%	-	1 hour
36	Passion fruit	0.625%	-	1 hour
37	HAM'S F-10	-	7.2-7.4	3-6 hours
38	Pedialyte	-		24 hours
39	Euro Collins	-	-	8 hours

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