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Review Article

Socket to Survival: Narrative Insights into Storage Media for Avulsed Teeth

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Abstract:

Dental avulsion, the complete displacement of a tooth from its socket, represents the most severe form of traumatic dental injury due to extensive damage to supporting structures. Immediate replantation is ideal, as extra-oral time is a critical determinant of treatment success and long-term prognosis. Effective management protocols must prioritize the viability of pulp and periodontal ligament (pdl) cells, as an unsuitable transport or storage medium significantly increases the risk of pdl cell necrosis, leading to complications like ankylosis and replacement resorption. Therefore, an informed selection of an appropriate storage medium is essential for a favourable outcome. This review aims to assess various available storage media, highlighting their advantages and disadvantages to identify optimal approaches for periodontal tissue preservation.

Keywords: *Dental Avulsion; Periodontal Ligament; Storage media; Traumatic Dental Injuries; Hank's balanced salt solution (hbss); saline; milk; egg white; coconut water; propolis; Replacement Resorption.*

Introduction

Traumatic dental injuries refer to damage to the teeth, gums, jaws, lips, or surrounding oral soft tissues.[1] Among tdi's, avulsion is considered one of the most severe forms as it signifies the complete exarticulation of a tooth from its socket caused by trauma, accounting for about 0.5–3% of all dental injuries.[2] The outlook for an avulsed tooth is greatly affected by the immediate treatment given after the injury. If immediate reimplantation cannot be performed, the avulsed tooth must be preserved in a suitable storage solution to maintain cellular health.[3]

A storage medium is defined as a biocompatible solution designed to mimic the oral environment and maintain the survival of periodontal ligament (PDL) cells after avulsion.[4] An ideal storage medium should maintain cellular integrity, possess antimicrobial features to reduce infection risk, and be easily accessible and affordable for emergencies.[5]

This review highlights the importance of awareness and education regarding storage media, examines the advantages and limitations of various options, and emphasizes the role of dental professionals in disseminating knowledge to improve outcomes in avulsion cases.

Methods

A literature review was conducted using PubMed/Medline, Lilacs, BBO, and SciELO databases to assess pdl cell viability following storage of avulsed teeth in different transportation/storage media. The search focused on English-language research articles, reviews, and laboratory studies (animal and human cell counting) published between 2000 and 2024, using the keywords: tooth avulsion, tooth replantation, transportation medium, storage medium, and natural storage media.

Types of storage media

The type of storage medium used following avulsion affects the prognosis of tooth replantation. As a result of the critical role of these storage media, an informed choice of a suitable medium is essential for successful replantation.

Classification of Storage Media[6]

Commercially available	Naturally available
1.Hank's Balanced Salt Solution	1. Saliva
2.Tooth Rescue Box	2. Tap Water
3. Contact Lens Solution	3. Milk
4. Gatorade	4. Coconut water
5. Via span	5. Propolis
6. Eagles Medium	6. Egg White
7. Normal Saline	7. Green Tea
8. Custodiol	8. Pomegranate Juice
9. Growth Factors	9. Aloe Vera
10. L Ascorbic Acid	10. Emdogain
11. Ricetral	11. Red Mulberry
12. Euro Collins	12. Soy Milk
13. Probiotics	13. Honey
14. Cryoprotective Agents	14. Saliva Officinalis
15.Autologous Serum	15. Dragon Blood Sap
16. Ringers Lactate	
17. St Thomas Cardoplegia	

Table 1: Classification of Storage Media

Naturally available

A) Saliva

Avulsed teeth can be temporarily stored in saliva to keep them from drying out. Weine claims that the best immediate transport medium for an avulsed tooth is the patient's own saliva.

1. pH is 7.4-7.79
2. Osmolality 60-70 mOsm/kg
3. Shelf life is less than 30-60 min

Adavantage: Immediate Accessibility

Disadvantage:

- Saliva is easily accessible, it can be employed as a storage medium for a brief amount of time
- Decreased osmolality (6070 mOsm/kg), which damages PDL cell membranes and induces edema makes it less acceptable as a storage medium

According to a study done by Lekic et al PDL cells from avulsed teeth kept in saliva for 30 minutes had a clonogenic capacity of 7.6%, and after 60 minutes, it was 1.5%.7

B) Tap water

Inadequate features of tap water, such as bacterial contamination, hypotonicity and non-physiological pH, and osmolality, promote the lysis of pdl cells.

1. pH is 7.4-7.79
2. Osmolality 30 mOsm/kg
3. Shelf life is less than 15-30 min

Advantage: Easily available

Disadvantage: Tap water has low osmolality of 30 mOsm/kg causing cellular swelling due to hypotonicity. A Study done by Blomlof et al discovered that, in contrast to saliva and milk, keeping cultured human pdl cells in tap water for one hour resulted in more PDL cell damage.8

C) Milk

Since milk is readily available in practically every circumstance, it is the most practical transport medium for the shortterm storage of avulsed teeth. Vitamins and amino acids are present in milk which can deactivate enzymes that are detrimental to pdl cells.

1. pH is 6.5-6.8
2. Osmolality 275 mOsm/kg
3. Shelf life: It loses its effectiveness after 2 hours

Advantage: Milk is a suitable preservation medium for the avulsed tooth for the reasons listed below:

I. Pasteurized milk has far fewer microorganisms and offers vital nutrients

II. Milk's capacity to sustain pdl cell viability is impacted by its fat content.

Disadvantage: Despite being widely accessible, it is uncommon in athletic settings where teeth avulsions could occur.

- A study by Moura CC et al. compared longlife whole milk and skim milk with pHadjusted coconut water and soy milk and found that longlife whole milk and skimmed milk had fewer PDL viability. 9
- In a study by Pearson et al., the ability of various milks to sustain the vitality of human periodontal ligament cells on avulsed teeth was compared to that of whole milk. At two hours, it was discovered that milk substitutes outperformed whole milk by a significant margin.[10]

D) Coconut water

A naturally occurring, sterile, and physiologically pure product is coconut water. Proteins, vitamins, minerals, and amino acids are all abundant in it. extensively used to replenish electrolytes (potassium, calcium, and magnesium) and fluids.

1. pH is 5-5.4
2. Osmolality 288-378 mOsm/kg
3. Shelf life: 1- 2 hours

Adavantage:

- Easily Available and Low Cost

Disadvantage: Following avulsion, the tooth must remain inside the coconut's shell; once it is visible, the liquid rapidly loses much of its nutritional and organoleptic properties and starts to ferment.

- It was discovered by Ali S. et al. that 100% mature coconut water was superior to 50% dilutions made from either young or mature coconuts.[11]

- Gopikrishna et al. found that coconut water maintained noticeably more viable periodontal ligament cells.[12]

E) Propolis

Bees utilize propolis, a multipurpose substance, to build and maintain their hives. Resin makes about 55% of its composition, followed by essential oils and wax (30%), pollen (5%), and miscellaneous components (10%).

1. pH is 5-6.5

2. Osmolality 280-360 mOsm/kg

3. Shelf life: 1- 2 year

Advantage: Anti-inflammatory, antibacterial, antioxidant, antifungal, and tissue-regenerative properties are among its many biological activities. Relatively non toxic.

Disadvantage: In a dog experiment, Casarato et al. found that in replanted teeth preserved in propolis, replacement resorption cannot be stopped.

- Khademi et al. found that 10% propolis was more effective than a 20% solution and more effective than milk, HBSS, tap water, and dmem [13]

- Thomsson et al. found that, when compared to cells kept in hbss, milk, or saline, propolis cells had the greatest variability.[14]

F) Egg white

Because of its high protein, vitamin, and water content, lack of microbial contamination, and ease of access, egg white is regarded as an excellent option for storage media for teeth undergoing delayed replantation.

1. pH is 8.6–9.3
2. Osmolality 258 mOsm/kg
3. Shelf life: 10 hours

Advantage: It is readily available

Disadvantage: Egg white as a storage medium suffers the setback of impracticality.

- De Sousa et al.'s microscopic investigation revealed no distinction in the maintenance of pdl cell viability on avulsed teeth between milk, egg white, and artificial saliva. 15
- Khademi et al. in order to stop inflammatory resorption in his study extracted thirty teeth from three dogs that had received endodontic treatment. Teeth were kept in egg white for six to ten hours were said to be more successfully repaired than those that were kept in milk. 16

G) Green tea

Green tea is a popular beverage which has many health benefits, mainly due to the presence of polyphenols that contribute to green tea's antiinflammatory and antibacterial properties, such as epicatechin, epigallocatechin, epicatechin gallate, epigallocatechin gallate, epigallate, and catechin.

1. pH is 6.6-7.8
2. Osmolality 87 mOsm/kg
3. Shelf life: 24hrs – freshly made, 6-12 months commercially

Advantage:

- It is readily available
- Adans et al. claim that epigallocatechin gallate has a greater ability to encourage positive reimplantation than hbss and can be employed effectively as a storage medium. 17

Disadvantage:

Because of its low osmolality, which can cause pdl cells to die, commercially available green tea is not a good choice for storing avulsed teeth.

Studies:

- Green tea produced good outcomes, according to Hwang et al. and Jung et al., maintaining 90% cell viability for up to 24 hours, which was comparable to the HBSS control. 18, 19

H) Pomegranate juice (punica granatum)

Pomegranates are regarded as "pharmacy unto itself" in ayurvedic treatment. It is a remarkable fruit whose juice, skin, and seeds all have full medicinal properties.

1. pH is 7
2. Osmolality 282 mOsm/kg
3. Shelf life: 6-24 hours

Advantage: It encourages robust cell adhesion and possesses powerful anti-inflammatory, anti-carcinogenic, and antioxidant qualities

Disadvantage: Its efficacy is very less, further research is needed for its role as a storage media

In their investigation, Tavassoli et al. came to the conclusion that pomegranates have an impact on the proliferation of fibroblast cells.At six hours, the greatest improvement in cell viability is seen. 20

I) Aloe vera

Aloe vera is a member of the Liliaceae family and resembles a cactus. The remaining 1-2% of the gel is composed of active ingredients such as aloesin, acemannan, aloeride, naftoquinones, amino acids, and vitamins, while the remaining 98-99% of the gel is composed of water.

1. pH is 4.5-5
2. Osmolality 280-300 mOsm/kg
3. Shelf life: upto 9 hours

Advantage: Naturally Available and Cost effective

Disadvantage: Accessibility

Pattamapun et al. in his study found that the pdl fibers close to the cementum of the tooth preserved in aloe vera were thicker and more intact than those of other teeth. 21

J) Emdogain

Emdogain is a gel made from the matrix proteins of fetal pig tooth enamel, primarily amelogenins It is an enamel matrix derivative, a specialized biomaterial that is sold commercially and is mainly used to encourage the regeneration of missing periodontal tissues.

1. pH is 7.4-7.7
2. Osmolality 300 mOsm/kg
3. Shelf life: 2 years when stored at 2°C – 8°C

Advantage: Delay the development of replacement resorption

Disadvantage: Failure to prevent replacement resorption and regenerate the damaged periodontal tissues.

- Studies as storage media is quite less
- In their 2001 study, Iqbal and Bamaas et al. examined histological characteristics and concluded that the emdogain group had a higher incidence of healed pdl than the control group. [22]
- Fridström et al. (2008) came to the conclusion that emdogain would still be useful for a straightforward healing process following replantation if there were better circumstances surrounding the storage medium and/or extra-oral time. [23]

K) Red mulberry (morus rubra)

The red mulberry tree, or Morus rubra as it is technically known, is indigenous to North America.Flavonoids, alkaloids, polysaccharides, and antioxidants that support cell preservation are among its constituents.

1. The ph is 4.3-5.0
2. Osmolality is 280-300 mOsm/kg
3. Shelf life is 24 hrs

Advantage:

- It has antioxidant and anti-inflammatory property,

Disadvantage:

- It has low pH, so it may cause cell lysis.
- Not easily available.

According to a Study by Ozan et al the effectiveness of 4.0% and 2.5% M. rubra at 3, 6, and 12 hours was found to be considerably better than hbss (P <.05) 24

L) Soy milk

Soybeans are used to make soy milk. It is free of lactose and cholesterol and has a very low content of saturated fat. It serves as a culture medium for biological reactions and cell division.

1. The ph is 7.0 – 7.4,
2. Osmolality is 258 mOsm/kg
3. Shelf life: 90% viability noted after 24hrs

Advantage: Easily available.

Disadvantage:

Its allergic reaction has been well-known. Specific studies are needed to verify its overall physiological compatibility and efficacy.

Silva et al.'s investigation revealed that soymilk's capacity to sustain viability was comparableto that of hbss and milk.[25]

M) Honey

Medicinal Value of honey to treat wounds and a variety of illnesses, such as aphthous ulcers, stomach ulcers, and chronic coughs was utilized in the ancient times.

1. The ph is 6.07
2. Osmolality is 280 mOsm/kg
3. Shelf life 6 months

Advantage:

- Antibacterial property.
- Easily Available and Cost Effective

Disadvantage:

It can cause cell lysis and it has a lower pH. • Because pure honey has a high viscosity and hyperosmolarity, making it unsuitable for cell preservation, "honey milk" is utilized instead of pure honey.

A study by Sheth et al. found that honey seems to be just as effective as hbss at storing avulsed teeth for up to six hours. [26]

N) Salvia officinalis

Salvia officinalis, commonly referred to as sage extract, possesses antioxidant and antibacterial qualities in addition to essential oil.

1. ph is 7-7.4
2. Osmolality is lesser than 280 mOsm/kg
3. Shelf Life: 1–3 h

Advantage:

- Antioxidant , Antimicrobial and Anti inflammatory properties
- Preservation of cell viability

Disadvantage:

- Uncertain Physiological pH and Osmolality
- More Studies are required to prove salvia officinalis as a storage media

A study by Ozan et al. indicated that compared to other experimental solutions, a 2.5% solution of S. officinalis was a more effective storage medium. 27

O) Dragon blood sap (croton lechleri)

Dragon's blood sap is derived from the Croton lechleri tree, is a medicinal plant.

1. The ph is 5.0 – 5.5
2. Osmolality is 270–290 mOsm/kg
3. Shelf life: Fresh 1-week, Dry extract 1- 2yrs

Advantage:

- It has anti-inflammatory, antioxidant and anticancer properties
- Has antimycotic, antiviral, antifungal, antibacterial, properties.

Disadvantage:

Not easily available and studies regarding its use as a storage media are still going on

Study: A study by Martins et al, showed efficacy of the sap in the preservation of the integrity of different cell membranes and has potential to maintain pdl cell viability.28

Commercially available

A) Hank's balanced salt solution (hbss)

HBSS is a pH balanced salt solution that contains glucose and all of the vital metabolites required for cell function. HBSS was first created in 1940 by John H. Hanks for scientific research. It contains calcium chloride, magnesium sulphate anhydrous, potassium chloride, sodium bicarbonate, sodium chloride, D-glucose, and potassium phosphate (monobasic).

1. The ph is 7.4
2. Osmolality is 280 mOsm/kg
3. Shelf life: 3 years

Advantage:

I. It can preserve cells and tissues for 24 h and both the pH (7.4)

II. Osmolality is around 280 m osmol kg-1which is ideal

HBSS is the only medium that can replenish metabolites in depleted pdl cells.

Disadvantage:

I. HBSS is utilized in research labs and is not easily accessible to the general public.

II. Some nations offer a unique kit called Save-A Tooth (Phoenix Lazerus Inc., Pottstown, PA, USA) for the emergency treatment of avulsed teeth.

III. The price, which is about 3000 Indian rupees, is another significant deterrent.

- Hwang et al. found that after storing cultivated human pdl cells in hbss media for 24 hours, there was 94% cell viability, which is regarded as an outstanding outcome. 29

- Pillegi et al. used extracted human teeth in their study and found that there was about 90% cell survival with hbss. 30

B) Tooth rescue box (dentosafe)

Tooth rescue boxes are filled with a ready-to-use nutrient solution allowing the pdl cells to survive.For up to 48 hours, it can be kept in the box.It has a culture medium that comprises salts, amino acids, glucose, and vitamins, just as the one used for islet cell transplantation.

1. The ph is 7.2-7.4

2. Osmolality is 280-320 mOsm/kg

3. Shelf life: 3 years

Advantage: It has been shown to maintain the vitality of pdl cells for up to 48 h at room temperature in vitro. At room temperature, it was reported to have a shelf life of 3 years

Disadvantage: High cost around $25 - $35 USD for 1 bottle and poor accessibility

Pohl et al. demonstrated that all teeth inserted into the Dentosafe solution healed with physiologic function quickly after avulsion, and they suggested that Dentosafe ought to be a common item in first aid kits.31

C) Normal saline

Isotonic saline has been used successfully as a storage medium by researchers in both in-vivo and in-vitro studies due to its non-toxic, non-irritating, and sterile characteristics.

1. The ph is 4.5-7

2. Osmolality is 280 mOsm/kg

3. Shelf life: 2 years

Advantage:

- It has a comparable osmolality to that of pdl cells.

- Easily Available

Disadvantage: Normal saline contains no nutrients and without essential nutrients like glucose, amino acids, and vitamins, pdl cells cannot sustain their normal functions for very long.

- Alaçam et al. discovered that normal saline was an inadequate medium since it lacked the glucose and metabolically necessary ions needed by pdl cells. 32

- Cvek et al. discovered that a tooth kept in regular saline for 30 minutes exhibited less resorption than a tooth kept dry for 15 to 40 minutes.33

D) Contact lens solution

Contact lens solution is a convenient preservation medium for teeth after avulsion injuries as these solutions are available in school or athletic grounds and at home, where most injuries occur.

1. The ph is 6.8-7.4

2. Osmolality is 280-290 mOsm/kg

3. Shelf life: Unopened- 2-3 years and opened 1-3 months

Advantage: They contain buffered, isotonic saline solutions with the addition of preservatives that may preserve the viability of pdl cells.

Disadvantage: Although a number of single bottle systems (SoftWear®, Ciba Vision Opti Care) have been investigated as temporary storage media for avulsed teeth, it has not been discovered that the capacity of various contact lens solutions to maintain cell viability varies substantially.

Literature regarding its use as a storage media is less

E) Gatorade

Gatorade is a brand of sports-themed food and beverage products manufactured by PepsiCo and distributed in over 80 countries

It consist of a mixture of water, sodium, sugar, potassium, phosphate, and lemon juice.

1. The ph is 2.91
2. Osmolality is 280-360 mOsm/kg
3. Shelf life: 6-9 months

Advantage: Gatorade preserves more viable cells both at room temperature and on ice.

Disadvantage: The pH is around 2.91 and osmolality of 407 mOsm/ kg which makes it a poor choice as a storage media as it will lead to cell lysis

- Harkacz et al. claim that because of its osmolality of 407 mOsm/kg and pH of 2.91, Gatorade did not prove to be a suitable storage medium for avulsed teeth. 34
- Chamorro et al. claim that pdl cells exposed to Gatorade may suffer damage to their delicate cellular membrane, which would prevent the cell from growing, because of the solution's low pH. 35

F) Viaspan

The ViaSpan (Belzer VWCSS, Du Pont Pharmaceuticals, Wilmington, DE, USA) is a medium used for transplant organ shipping and has proven to be a very successful storage solution for avulsed teeth.

1. The ph is 7.4
2. Osmolality is 320 mOsm/kg
3. Shelf life: Clonogenic capacity is high till 8 hours ,65% is reduced at 24hr

Advantage: ViaSpan has osmolality of 320 mOsm/kg and pH is around 7.4 at room temperature which is ideal for the cellular growth.

Disadvantage: Due to its high cost (USD 300 per litre), short shelf life (a couple of months) and difficulty to find, makes it difficult use as a storage medium.

Ashkenazi et al evaluated the efficacy of various storage media and found that the vitality, mitogenicity, and clonogenic potential of pdl fibroblasts maintained for up to 24 hours at room temperature were best preserved

by culture medium, followed by hbss and ViaSpan. [36]

G) Eagle's medium

This well-known synthetic cell culture medium was developed by Harry Eagle. Which contains vital amino acids and other ingredients, and its basic formulation is based on Earle's salts. A number of changes have been made to this fundamental medium, including the more enriched Dulbecco's Modified Eagle Medium.

1. The ph is 7.2-7.4
2. Osmolality is 290–310 mOsm/kg
3. Shelf life: 6-12 months

Advantage: Eagles Medium contains amino acids, vitamins and bicarbonates. Bicarbonates present act as a buffer.

Disadvantage:

- It is not easily available and its need of refrigeration makes it difficult to use as a storage medium
- Pearson et al. demonstrated that soaking teeth in Eagles Medium for as long as 60 minutes improved pdl repair compared to immediately replanting the teeth. [10]
- Lekic et al. discovered that, when stored in em as opposed to several alternative media, the greatest number of viable cells appeared after 30 and 60 minutes. [7]

H) Custodiol

Custodiol is a histidine-tryptophan ketoglutarate solution with high flow properties and low potassium content. It is the registered trademark of Dr. Franz.

1. The ph is 7.02 – 7.4
2. Osmolality is 310 mOsm/kg
3. Shelf life: 2 years, 24 hr once opened

Advantage:

I. It serves as an organ preservation solution

II. Its composition is comparable to that of extracellular fluid, which enables it to carry out extremely precise tasks that support the body's general homeostasis and general health.

III. Its osmolality of 310 mosmol L aids in preventing dehydration and cell damage.

Disadvantage:

- Not easily available and therefore of little value as a storage medium for avulsed teeth.
- Alaçam et al. found that Custodiol and HBSS seemed to be appropriate transport media for preserving cell viability. [37]

I) Growth factors

Growth factors are signaling proteins that aid in controlling the migration, survival, differentiation, and proliferation of cells. These elements are essential for encouraging the injured periodontal ligament's (PDL) regeneration and recovery.

1. The ph is 7.2– 7.4
2. Osmolality is 280–320 mOsm/kg
3. Shelf life: 6–12 months at -80°C (frozen); hours to days at 4°C (solution)

Advantage: The use of polypeptide growth factors, which functions as a potent biological mediator regulating numerous activities of the wound healing, has been suggested for the promotion of pdl regeneration

Disadvantage: Prohibitively expensive for routine emergency use and not easily accessible

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 apparatus 5–10 fold during the early phase of wound healing. [38]

Their application is currently limited to highly specialized research

J) L ascorbic acid

L-Ascorbic acid, commonly known as Vitamin C, plays a significant role in the healing and regeneration processes following a tooth avulsion, primarily due to its multifaceted biological functions.

1. The ph is 5-6

2. Osmolality is 280-320 mOsm/kg

3. Shelf life: Short, highly sensitive to oxygen, light, heat and metals

Advantage: Ascorbic acid stimulates osteoblasts to lay down Type I collagen and also helps in expression of specific markers associated with osteoblastic phenotypes such as alkaline phosphates and osteocalcin.

Disadvantage: As type I collagen production is considered an initial process in the differentiation of pdl cells, it may serve as a potential storage media.

Ishikawa et al. stated that ascorbic acid increases the alp activity, which is required for binding of pdl cells to type 1 collagen via α2β1 integrin thereby serving it as a potential storage media. [39]

K) Ricetral

Ricetral contains glucose and vital salts and is an oral rehydration formula.

1. The ph is 7.2 – 7.4

2. Osmolality is 280 – 320 mOsm/kg

3. Shelf life: Unopened – 1year Opened – few weeks

Advantage: Supports PDL viability. Glucose and vital salts maintain rehydration

Disadvantage: Effective only for short durations (~1–2 hours) Not much studies on its efficacy

According to a study by Rajendran et al, cell vitality was high with Ricetral and hbss, but poor with milk. 40

L) Euro collins

Euro-Collins solution is a preservation solution historically used for flushing and storing organs like kidneys, livers, and pancreases before transplantation. It is a hypothermal medium.

1. The ph is 7.4

2. Osmolality 420 mOsm/kg

3. Shelf life- Unopened 2 yrs, Opened – 1hr

Advantage:

- Supports viability

- Used in organ preservation, hence proven for cell viability high pdl viability (similar to hbss) for up to

24 hours in vitro

- Have a buffering capacity that prevents pdl cell acidosis

Disadvantage:

- Expensive
- Not easily available
- Refrigeration required

According to study by Sottavia et al, Euro-Collins solution was found to be an adequate storage medium for keeping avulsed teeth for up to 8 hours before replantation.[41]

M) Probiotic solution

Probiotics are living microorganisms, principally bacteria that have beneficial effects on human health, beyond basic nutrition.

1. The ph is 4.0 – 5.5
2. Osmolality is 300–360 mOsm/kg
3. Shelf Life- 6–12 months

Advantage:

- Maintains pdl cell viability
- Antibacterial and anti-inflammatory properties
- Readily available in probiotic drinks or sachets
- Biocompatible

Disadvantage:

- Needs refrigeration
- Low pH

- Variabilty between brands

Caglar E et al, in his study concluded that probiotic solutions (e.g., Lactobacillus reuteri) preserved pdl cell viability nearly as well as hbss. [42]

N) Cryoprotective agents

Cryoprotective agents are used to prevent ice formation, which causes freezing damage to the biological tissue when cooling the organs. Examples are dimethyl sulfoxide (dmso), glycerol, ethylene glycol, and propylene glycol

1. The ph is 7-7.4
2. Osmolality is 280-320 mOsm/kg
3. Shelf Life- 6-12 months

Advantage: Prevent ice crystal formationviability and differentiation potential of cells

Disadvantage: Toxic to cells at high concentrations

When the effects of the cryopreserving agents, 5% and 10% dimethyl sulfoxide and 10% glycerol, was studied by Schwart and Andreasen et al it was seen that these agents when used under controlled freezing temperature helped in the preservation of pdl of reimplanted teeth.[43]

O) Autologous serum

The patient's own serum can be used as storage medium. Autologous serum refers to the liquid component of blood (serum) that remains after the blood has clotted. This serum is extracted from a patient's own blood and diluted with a sterile solution.

1. The ph is 7.35 – 7.45
2. Osmolality 285 – 295 mOsm/kg
3. Shelf life- Use within 2–4 hours.

Advantage:

- It is rich in nutrients, proteins, and growth factors which helps in promoting PDL cell survival
- It is excellent for short-term (1–2 hours)

- Has clonogenic capacity.

Disadvantage:

- Shorter shelf life
- Lekic et.al, found that autologous saliva + serum can maintain more than 3% clonogenic capacity which is important for healing.[7]

P) Ringers lactate

Ringer's lactate solution, also known as Lactated Ringer's or Hartmann's solution, is a sterile solution used for fluid and electrolyte replacement in patients who have low blood volume or low blood pressure.

1. The ph is 6-7.5
2. Osmolality 273-280 mOsm/kg
3. Shelf Life 18-36 months

Advantage:

- Osmolality and pH is close to natural body fluids
- Maintains pdl cell viability for 30–60 minutes
- Easily available

Disadvantage:

- Lacks nutrients and growth factors
- Only for short period < 60mins

Pravin et al, found maximum number of viable pdl cells shown by teeth stored in Infant Milk Formula, followed by Ringers Lactate, Egg White, Oral Rehydration Salt, and Dextrose normal saline.[44]

Q) St thomas cardoplegia

St. Thomas' cardioplegic solution is a type of crystalloid cardioplegia used to protect the heart during surgery.

1. The ph is 7.8
2. Osmolality 340 mOsm/kg
3. Shelf Life- 2years

Advantage:

- Used mostly Heart transplant
- Can maintain Pdl cell viability

Disadvantage:

- Short stability and researches are limited

According to Aditi et al, hbss had the highest number of viable pdl cells, than St. Thomas cardioplegia solution. [45]

Conclusion

The prognosis of an avulsed tooth is largely determined by the duration of its extra-oral period and the storage medium employed prior to replantation.

When recommending an appropriate storage medium for an avulsed tooth, it is essential to consider the specific circumstances and location of the accident, as availability and practicality often dictate the choice. Pediatric dentists play a pivotal role in educating parents, caregivers, and children on the immediate management of dental avulsions, with emphasis on gentle handling of the tooth and its prompt storage in a suitable medium.

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