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REVIEW ARTICLE

Extra-Alveolar Storage Media for teeth: A Literature review.

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Abstract

An intentional replant is a tooth extracted then replaced after treatments, such as root canal therapy; while an accidental replant is a tooth replaced after being knocked out accidentally. The maintenance of the vitality of the periodontal ligament cell is essential for the long-term success of a transplant or replant. An appropriate storage medium should maintain or improve the vitality of the cells during the extra-alveolar period. Different types of wet storage media have been investigated, such as Hank's Balanced Salt Solution, viaspan, culture media, saline; natural products like water, saliva, bovine milk and its variations, propolis, green tea, Morusrubra, egg white, coconut water; rehydrating solutions etc. This Literature review outlines the storage media that are available and highlights their specific features or problems.

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1. Introduction

Traumatic dental injuries represent one of the most common reasons for emergency appointments in dental practice, and ensuring the survival of traumatized teeth is one of the main responsibilities of dentists and also physicians. Eighteen percent of injuries in preschool children are due to oral trauma,^{1,2} of which 1%–16% consist of avulsions.^{1,3} Tooth avulsion is characterized by complete displacement of a tooth from its socket as a result of trauma. When dental avulsion occurs, immediate replantation at the trauma site is the ideal procedure for maintaining the viability of periodontal ligament (PDL) cells. However, immediate replantation is rarely achieved,⁴ principally because of various associated factors such as the person's conscious state, lack of first aid knowledge, informed consent issues and lack of confidence in strangers gathered at the scene of accident, it is not always feasible to replant the tooth immediately.⁵ The viability of PDL cells relies on three critical factors: the duration of extra-alveolar time, preservation of the root and storage media of the tooth, all of which determine the prognosis for dental replantation.^{4,6-8} Inflammatory resorption and replacement resorption along with dental alveolar ankylosis are the most significant and common complications after replantation of avulsed teeth.^{6,7} Success of replantation was initially thought to be mainly associated with the speed with which the tooth is replanted i.e. shorter the extra alveolar time, better the prognosis but it is changed with time and researchers have demonstrated that storage medium is one of the most important factor than the extra oral time as short period of dry storage shows comparatively poor prognosis than the prolonged storage in a suitable medium.⁹

A storage medium may be defined as a physiological solution that closely replicate the oral environment to help preserve the viability of PDL cells following avulsion.¹⁰ Different types of Extra-Alveolar storage media for Intentional (tooth extracted then replaced after treatments) and accidental (avulsed tooth) replants procedure have been investigated, which may vary from cell and tissue culture solutions like Hank's Balanced Salt Solution (HBSS); medical/hospital products developed specifically for organ storage purposes, such as Viaspan, Custodiol

and Euro-Collins; culture media, like Minimum Essential Medium (MEM) such as Eagle's MEM; saline; natural products like water, saliva, Milk and its variations, propolis, green tea, Morusrubra (red mulberry), egg white and coconut water; rehydrating solutions, like Gatorade and Ricetral, and even contact lens solutions. This paper reviews the literature on the different storage media that have been investigated for avulsed teeth considering their characteristics, efficacy and accessibility.

2. Types of storing environments

2.1 Tap water

Among the studied transport media for tooth, tap water has shown to be the one with the least desirable results because it has bacterial contamination, hypotonicity, and non-physiological pH of 7.4 to 7.79 and an osmolality of 30 mOsmol Kg⁻¹, which causes rapid PDL cells lysis.¹¹⁻¹³ Although some studies have suggested that it may be accepted as a transport medium for very brief periods of time when there are no alternatives,^{14,15} it should be remembered that it is the least desirable transport medium⁶ available and its use will lead to ankylosis and replacement resorption.

2.2 Saliva / Buccal Vestibule

Human saliva has unfavorable characteristics, such as non-physiological pH and osmolality (lower than the physiologic i.e. 60-70 mOsmol Kg⁻¹), high microbial contamination and hypotonicity.^{11,12,16,17} Storage of avulsed teeth in saliva for 2 to 3 hours causes swelling and membrane damage of PDL cells¹⁸. However, saliva storage produces one-third less cell damage than dry storage or storage in tap water, so it is preferable to use it rather than keep the tooth in dry conditions. Saliva can be considered to be an acceptable short-term storage medium (less than 30 min) and its use should be limited to cases where the extra-alveolar duration is less and other superior storage media are not available.¹⁹

2.3 Normal Saline

The saline solution provides physiological pH and osmolality of 280 mOsmol Kg⁻¹. Which is compatible to the cells of PDL, but lacks essential nutrients such as magnesium, calcium and glucose; necessary to the normal metabolic needs of the cells of the PDL.²⁰

Blomlof²¹, Courts et al.²², Krasner²³ have stated that saline solution was harmful to the cells of PDL in avulsed teeth if it is used for longer than two hours. Saline may be easily encountered in a variety of places; with this wide availability, it is more convenient to use them for short periods than let the tooth dry out.

2.4 Gatorade

It's a sports drink used for rehydration. Because of its low pH (around 2.91) and hyper tonicity (osmolality of 407 mOsmol Kg⁻¹), it did not turn to be an adequate storage medium for avulsed teeth.²⁴ Gatorade preserves more viable cells than tap water but fewer than all other media, both at room temperature and in ice.²⁵ Gatorade can only serve as a short time storage medium if other more acceptable media are not available.

2.5 Contact Lens Solution

It is a fatty acid monoester and a cationic antimicrobial component. The contact lens solutions were worse than saline solution, milk, and HBSS.²⁶ The presence of preservatives in its formula was harmful to the cells of the PDL²⁵ and they are not commonly recommended.

2.6 Morusrubra (red mulberry)

This fruit contains greater amount of flavonoids, alkaloids and polysaccharides in addition to antioxidant substances.¹² Though studies had showed promising results as storage / transport media for avulsed teeth, their lack of availability limit their indication and its biological properties have not been established yet. Further research is necessary before its use can be recommended.^{12,27}

2.7 Probiotic solution

'Probiotics' are defined as living microorganisms, principally bacteria, that are safe for human consumption & when ingested in sufficient quantities, have beneficial effects on human health, beyond basic nutrition.²⁸ Caglar et al tested the viability of fibroblasts using HBSS, saline, Lactobacillus reuteri solution, and milk and concluded that there was no significant difference in the number of viable PDL cells between HBSS, milk, L. reuteri solution, and saline. Within the parameters of their study, it appears that probiotic may be able to maintain PDL cell viability as HBSS, milk, or saline.²⁹ However further studies are required to confirm its beneficial effect

2.8 Green tea extract (GTE)

Green tea extract from Camellia sinensis is widely consumed beverage throughout the world second only to water. Green tea extract has been reported to have remarkable anti-inflammatory, antioxidant, anticarcinogenic effects and to prolong allograft survivals. Interestingly, GTE showed the best ability for storage of avulsed tooth although the osmolality and pH were not ideal.³⁰ Hwang et al.³⁰ and Jung et al.³¹ in the search for a storage medium capable of minimizing the infections after tooth replantation, maintaining PDL cell viability and reducing root resorption and ankylosis, reported enthusiastic results with green tea, with the maintenance of 90% of cell viability for

up to 24 h, similar to the HBSS control. Jung et al.³¹ also observed that the higher the extract concentration the more efficient the medium. In view of their study, the use of green tea extract and its compounds may be a suitable, alternative storage medium for the conservation of avulsed teeth, but further *in vivo* research is necessary before its use can be recommended.

2.9 Ricetral

Ricetral is a commercial oral rehydration formulation, which contains essential nutrients like glucose and vital salts in concentrations considered adequate for the cell metabolism. Rajendran et al.³² evaluated the PDL cell viability of extracted human teeth by the Trypan blue exclusion method and the results showed that the ability of Ricetral to retain PDL cell vitality is similar to HBSS and both these solutions are better than milk.³² Further research is necessary before its use can be recommended to confirm its efficacy.

2.10 Culture medium

Eagle's Minimal Essential Medium containing 4 mL of L-glutamine - 105 IU/L of penicillin; 100 µg/mL of streptomycin, 10 µg/mL of Nystatin, and calf serum (10% v/v)—demonstrated that the cell culture medium (Eagle's medium at 37°C) can preserve PDL fibroblasts for extended periods before reimplantation.³³⁻³⁵ Teeth preserved in the culture for 5 to 7 days showed significantly reduced levels of inflammatory resorption. The mechanism at work could be the proliferation of vital parts of the PDL cells to cover areas of the root surface denuded of periodontal membrane or areas covered by necrotic periodontal membrane.¹⁹ Pohl et al.³⁶ investigated the suitability of specially composed cell culture media for storage of extracted teeth for up to 48 hours. Auto radiographic investigations revealed that the proliferative activity of periodontal ligament (PDL) cells of teeth stored in cell culture medium for up to 48 hours increased with storage time. This cell culture medium was reported to preserve cell viability of PDL cells adhering to extracted teeth for at least 48 h.³⁶ Culture media possess a superior capacity to maintain the health of the PDL cells. Although culture media have shown promising results as storage media, availability at the trauma site is a practical issue, but can be used for tooth autotransplantation procedures.

Tooth autotransplantation is the process in which tooth, usually impacted, is surgically transferred to correct position, or to replace another tooth, in the same alveolus transplants and replants. This involves removing the tooth, creating a new socket in the same alveolar bone and repositioning the tooth. The tooth is stored in an appropriate storage medium to preserve the periodontal membrane and cementum of the root during the extra-alveolar period when the new socket is being prepared.³⁷⁻⁴⁰

2.11. Growth factors

The use of growth factors supplemented in storage media can function as potent biological mediators for the promotion of PDL regeneration. Ashkenazi et al.³⁴ observed, after 24 h of storage in different storage media supplemented with growth factors, that there was an increase in the mitogenicity of PDL fibroblasts by 20 to 37%. The same trend was observed in the clonogenic capacities of fibroblasts stored in media supplemented with growth factors. However, this supplementation did not increase the mitogenic capacity of PDL fibroblasts stored at room temperature for 2 to 8 h. Thus, supplementation of growth factors in storage media improved the effectiveness of the media only when the storage period was long (more than 24 hours). For short periods of storage (2 to 8 h), the use of media without growth factors is preferable.¹⁹ However addition of growth factors on storage media need to be manufactured and distributed for clinical use.

2.12 Ascorbic acid

Ishikawa et al.⁴¹ studied the effect of ascorbic acid on PDL cells and observed that ascorbic acid increased the ALP activity, which is required for the binding of PDL cells to type I collagen via $\alpha 2\beta 1$ integrin, whose expression is again increased by ascorbic acid. As type I collagen production is considered to be an initial process in differentiation of PDL cells, it may serve as a potential storage medium.¹⁹

2.13 L-DOPA (levodopa)

L-DOPA (levodopa) is a drug with possible mitogenic effects. Mandana et al.⁴² observed the effect of levodopa on human PDL fibroblasts and indicated that levodopa can also have a local effect on the growth of cells, including the PDL cells, and can preserve as a preserving medium for avulsed teeth.

2.14 Cryoprotective agents

Mature teeth can be replanted after cryopreservation and can heal *in vivo* with a normal PDL, provided that a cryopreservative is used. Schwartz and Andreasen⁴³ studied the effects of the cryopreserving agents (cryoprotectives) 5% and 10% dimethyl sulphoxide (DSMO) and 10% glycerol, on PDL. They observed that the use of different cryoprotectives, combined with controlled freezing rates to -196°C, can preserve the PDL of the replanted teeth to a greater or lesser extent.¹⁹

2.15 Patients own serum

Thonner⁴⁴ proposed the use of the patient's serum as a storage medium, He claimed that the histological picture of the periodontium of a freshly extracted tooth showed that the cementum and periodontal tissue present

over the root are well vascularized. The histologic picture after the tooth had been preserved in serum for about one hour showed that the tissues still stained well, indicating that serum can maintain the vitality of the periodontal membrane during the critical extra-alveolar period during tooth transplant or replant procedure.

2.16 Catalase supplementation

Buttke and Trope⁴⁵ observed that supplementation with catalase resulted in significant reduction of surface resorption. It is suggested that roots stored in antioxidant demonstrate lower levels of surface resorption. As some storage media contain hydrogen peroxide, which may be toxic to PDL cells, addition of an antioxidant such as catalase can have beneficial effects on PDL cells.¹⁹

2.17 Propolis

Propolis is a natural substance produced by honeybees with remarkable antioxidant, anti-inflammatory, antimicrobial and tissue regenerative actions. Martin and Pileggi reported that teeth stored in propolis demonstrated the highest viability for PDL cells, when compared to milk, saline or HBSS.⁴⁶ It can inhibit the late stages of osteoclast maturation so it may be useful as an intracanal medicament to reduce resorption of traumatized teeth.⁴⁷ Casaroto et al.⁴⁸ reported good results for maintenance of cell viability, but the root resorptions were visible, which compromises its efficacy for this purpose. On the other hand, Gopikrishna et al.⁴⁹ found that propolis had 50% efficacy in maintaining cell viability. Such variation of results may be explained by the complex chemical composition of propolis, which varies according to the location of plants, climate and even the seasons that define the different quantities of volatile oils, waxes, resins, balms, pollen, vitamins and sugars.⁵⁰ More over propolis has no standard recommended weight per volume of solution also. It has been reported that 10% propolis was more effective than a 20% solution.⁵¹ A recent investigation showed that propolis could be used for avulsed teeth and that a 6-h period of storage was more appropriate than 60 min of storage.⁵²

Propolis is a promising medium for the maintenance of PDL cell viability. The major disadvantage of propolis is that it is not readily available to the public and therefore of little value as a storage medium for avulsed teeth. Further research required to improve its applicability and widen its indication of use.

2.18 Coconut water

Coconut water is biologically pure and sterile, with a rich presence of amino acids, proteins, vitamins, and minerals. This natural isotonic fluid is available in its natural form directly from the coconut or in long shelf life packages and plastic bottles, mainly in tropical countries. Gopikrishna et al. observed that coconut water was superior to HBSS, milk or propolis in maintaining the viability of PDL cells^{49,53}. Thomas et al.⁵⁴ found that 15 to 120 min storage in coconut water is as efficient as storage in HBSS. On the other hand, Pearson et al.¹³ and Thomas et al.⁵⁴ observed that inflammatory resorption was more frequent when the tooth was maintained in coconut water compared with milk. Moreira-Neto et al.⁵⁵ observed that coconut water has an acidic pH of 4.1, which is deleterious to cell metabolism and concluded that the capacity of the storage media in maintaining human fibroblast cell viability in a decreasing order was milk > saline and coconut water with sodium bicarbonate > coconut water > mineral water⁵⁵ and Souza et al.⁵⁶ also reported that milk presented a better performance than coconut water in relation to the cell viability. It is therefore difficult to consider coconut water as an adequate storage medium for avulsed teeth because of the difficulty of neutralizing the coconut water to obtain a pH of 7.0 under clinical condition.

2.19 Egg white

Khademi et al.⁵⁷ compared milk and egg white as solutions for storing avulsed teeth, and the results have shown that teeth stored in egg white for 6-10 h had a better incidence of repair than those stored in milk for the same amount of time. Egg white has a pH of 8.6–9.3 and its osmolality is 258mOsmol Kg⁻¹. No significant difference between egg white and HBSS at storage times of 1, 2, 4, 8 and 12 h has been established and egg white was more suitable than water and milk. There was also no difference between egg white and Ca²⁺/Mg²⁺ free HBSS.⁵⁸ Cellular growth occurs at an osmolality of 230-400 mOsmol Kg⁻¹ and a pH of 6.6-7.8, but its optimal growth happens at an osmolality of 290-300 mOsmol Kg⁻¹ and pH of 7.2-7.4. The osmolality of the egg white is between 251 and 298mOsmol Kg⁻¹.⁵⁷ Sousa et al.⁵⁹ found no difference between milk, egg white and artificial saliva. Some experiments indicate that egg white is a very good medium to maintain cell viability, but others show a small loss of efficacy overtime, possibly due to egg's high pH and also because the PDL cells could target the several egg proteins as strange bodies. Further studies are required to confirm these adverse effects, as there are wide variations in egg composition and quality.⁵⁰

2.20 Hank's balanced salt solution (HBSS)

HBSS is essentially a pH-balanced salt solution contains ingredients, such as glucose, calcium, and magnesium ions, which can sustain and reconstitute the depleted cellular components of the PDL cells.³⁴ It can preserve cells and tissues for 24 h and both the pH (7.4) and the osmolality (280mOsmol Kg⁻¹) are ideal.^{58,60} According to Ashkenazi et al, HBSS was the most effective medium for preserving viability, mitogenicity, and

clonogenic capacities of PDL cells for up to 24 h at 4°C when compared with other solutions.³⁵ Hwang et al.³⁰ reported 94% cell viability after storage of cultured human PDL cells for 24 h in this medium, which is considered an excellent result. Pillegiet al.⁶¹ observed approximately 90% cell viability. The Save-A-Tooth solution, which contains HBSS, showed inferior results than the original product,^{62,63} which may be explained by the fact that HBSS is prepared for immediate use, when it has a better performance. However, HBSS use is restricted to laboratory environments and is not readily available at an accident site, which makes it impracticable as a storage medium for avulsed tooth.⁵⁰ Cost is also a major prohibitive factor.

2.21 Viaspan

Viaspan, a new storage medium presently used for organ transplant storage,¹⁴ has proved to be an extremely effective cold storage medium for organs before replantation.⁶⁴ ViaSpan has osmolality of 320 mOsm/kg, which enables excellent cellular growth. Its pH is around 7.4 at room temperature, which is ideal for the cellular growth.³⁵ It also contains adenosine, which is necessary for cell division.⁶⁵ Both HBSS and Viaspan proved to be superior to milk, with Viaspan clearly indicating the most effective medium with 37.6% vital fibroblasts after 168 hours of storage, thus showing a potential value as a superior long-term storage medium.¹⁴ Generally, Viaspan is considered as a medium close to ideal, but it must be refrigerated, it has a high cost and it is not readily available to the general public, especially at the moment of the accident, makes it difficult to use.^{50,66}

2.22 Custodiol

Custodiol is a histidine-tryptophan ketoglutarate solution with high flow properties and low potassium content. It is used as a preservation solution for organ transplantation. It is intended for perfusion and flushing of donor organs prior to removal from the donor and for preserving these organs during hypothermic storage and transport to the recipient.⁶⁶ Its composition is similar to that of extracellular fluid. It has an osmolality of 310 mOsmol Kg⁻¹.⁶⁷ Custodial is comparable to HBSS for cell preservation.⁶⁸ However, it is not available to the public and therefore of little value as a storage medium for avulsed teeth.

2.23 Conditioned Medium

Conditioned Medium is derived from the supernatant of human gingival fibroblasts grown in culture. It may contain stimulatory factors derived from the gingival fibroblast cells themselves so it is possible that these growth factors could have a stimulatory effect on the remaining cells on the root surface. It has been shown that this material is a superior medium for the extended storage of dog's teeth.^{69,70} It is not readily available to the public at an accident site, which makes it impracticable as a storage medium for avulsed tooth.

2.24 Euro-Collins

Euro-Collins solution is a hypothermal medium developed for preserving organs to be transplanted. Sottovia et al.⁷¹, in a histological and histometric analysis of avulsed dog's teeth stored in the Euro-Collins solution, observed similar results to those observed after immediate replantation, with good repair of supporting tissues, repair and reorganization of vessels and PDL collagen fibers and neoformation of cementum. Their lack of availability and high cost make their routine use unviable, and thus these solutions are used in very special cases, such as tooth autotransplantation procedures and laboratory studies.

2.25 Milk and Milk formulas.

Milk has several favorable characteristics as a transport medium for avulsed teeth, as it is an isotonic liquid with an approximately neutral pH (6.5 to 7.2) and physiological osmolality (270 mOsmol Kg⁻¹), has low or no bacterial content, contains growth factors and essential nutrients for cells, in addition to having a high availability mostly everywhere and low cost,^{11,12} but it is important that it is used in the first 20 min after avulsion.¹¹ Milk only prevents cell death rather than restoring normal morphology and ability to differentiate and mitosis. Gamsen et al.⁷² showed that milk is able to maintain the osmotic pressure for periodontal ligament cells but it does not have the ability to reconstitute depleted cell metabolites and restore viability. Blomlofet al.²¹ found that milk was a compatible storage medium for periodontal ligament cells, only when it was cold and fresh. Hiltz and Trope⁷³ showed that fibroblasts stored in milk remained vital but their morphology was distorted. They speculated that the mitotic capacity of the cells would be diminished. Milk can potentially maintain PDL cell viability for up to 2 hours.²¹ The vitality, clonogenic and mitogenic capacity of PDL cells in milk are similar to the values for HBSS. Cooler temperatures reduce cell swelling, increase cell viability and improve PDL cells recovery.⁷⁴ Harkaczet al.²⁴ showed that milk with lower fat content may be more appropriate at maintaining cell viability than milk with higher fat content.

Regarding the different milk preparations, Marino et al. reported that there was no significant difference between regular pasteurized milk and long shelf-life ultra-high temperature pasteurized whole milk at any time period. Regular pasteurised milk has a short shelf life and requires refrigeration, which makes it less readily available at the trauma site. Thus a long shelf-life milk having identical composition, pH, and osmolality to regular milk with a storage capability of 6 months without the need for refrigeration has gained more acceptance.⁷⁵ Pearson

et al compared the efficacy of several milk substitutes, which included reconstituted powdered milk, evaporated milk or one of two baby formulas: Similac or Enfamil; compared to whole milk and reported that Enfamil does not require special storage, has a shelf-life of 18 months and is a more effective storage medium in maintaining the viability of human PDL cells than pasteurized or whole milk for at least 4 hours.¹³ The drawbacks are that milk needs to be fresh and kept refrigerated, it does not replace depleted cell metabolites, and it does not facilitate cell mitosis. However several authors that evaluated the viability of PDL cells in contact with milk have reported 70 to 90% survival rates and low frequency of root resorptions after periods up to 72 h.⁵⁰ Therefore milk, chilled or otherwise, can be used as a storage medium of choice for short term extra-alveolar storage of avulsed tooth, since it is readily available to the public in most situations.

3. Discussion

The most crucial factor for the success of reimplanted tooth is the maintenance of PDL viability during the extra-alveolar period. The tooth is stored in an appropriate storage medium to preserve the vitality of PDL cells during the extra-alveolar period. The use of an inappropriate storage medium potentially increases the risk of PDL cell death, which can result in ankylosis or replacement root resorption. The search for a single, ideal storage medium that is capable of maintaining PDL cell viability, while presenting clonogenic capacity, antioxidant property, no or minimal microbial contamination, compatible physiological pH and osmolality, high availability, ready accessibility and low cost, is one of the main interests of dental trauma research.⁵⁰ Table 1 summarizes the pH, osmolality, characteristics, ease of access and efficacy of some solutions that have been proposed and /or tested as storage / transport media for Intentional and accidental replants procedure. Although HBSS, Solutions for organ transport and Eagle's medium have great potential to maintain the PDL cells in a viable state. They are expensive, not easily available and have a limited shelf life. Propolis, green tea, egg, coconut water, morusrubra, ricetraetc. need more studies to confirm its efficacy. However, no medium is ideal and in vivo studies are inadequate.

SL No.	Storage media	pH	Osmolality (mosmol kg ⁻¹)	Characteristics	Ease of access	Efficacy
1	Tap water	7.4	3	Microbial contamination	++	Very poor
2	Saliva	Non-physiological	60-70	Microbial contamination	++	Very poor
3	Normal Saline	Physiological	280	No essential metabolite	+	Poor
4	Gatorade	2.91	407	Has glucose, low pH	+	Poor
5	Contact Lens Solution	Physiological	Not established	Antimicrobial property, preservative	+	Poor
6	Morusrubra	Not established	Not established	Antioxidant property	-	Good
7	Probiotic solution	Not established	Not established	Basic nutrition present	-	Good
8	Green tea extract	Non-physiological	Non-physiological	Anti-inflammatory, antibacterial and antioxidant properties	-	Excellent
9	Ricetral	Not established	Not established	Has essential nutrients	+	Good
10	Culture medium	Physiological	Physiological	Nutrients, antimicrobial property & growth factors	--	Excellent
11	Growth factors	Not established	Not established	Increase the mitogenicity	--	Good
12	Ascorbic acid	Low pH	Not established	Increase type I collagen production	-	Not established
13	L-DOPA	Not established	Not established	Promote growth of PDL cells	--	Not established
14	Cryoprotective agents	--	--	Not established	--	Not established

15	Patients own serum	Physiological	Physiological	Has essential metabolites	+	Good
16	Catalase supplementation	Not established	Not established	Antioxidant property	--	Not established
17	Propolis	Not established	Not established	Anti-inflammatory, antibacterial and antioxidant properties	-	Excellent
18	Coconut water	Non-physiological	372	Sterile and contain nutrients	+	Good
19	Egg white	8.6 to 9.38	258	Low microbial contamination, contains nutrients and water	+	Good
20	Hank's balanced salt solution	7.4	280	Has essential metabolites & glucose	--	Excellent
21	Viaspan	7.4	320	Favorable to cell growth	--	Excellent
22	Custodiol	Physiological	310	Favorable to cell growth	--	Excellent
23	Conditioned Medium	Not established	Not established	Contain growth factors	--	Good
24	Euro-Collins	7.4	420	Favorable to cell growth	--	Excellent
25	Milk and Milk formulas	6.5–7.2	Physiological 270	Small bacterial contents, growth factors and nutrients	+	Excellent

Table 1 The comparison of pH, osmolality, characteristics, ease of access and efficacy of some solutions that have been proposed and /or tested as storage / transport media for Intentional and accidental replants procedure.

4. Conclusion

The tooth storage media that are mostly favoured when comparing Efficacy (in maintaining PDL cell viability) in the literature include: Eagle's culture medium = Viaspan = Euro collins = Custodiol = HBSS > Milk ≥ Propolis ≥ Green tea ≥ Egg > coconut water ≥ Ricetral. Based on the current literature, when comparing the practicalities of using these solutions, cost-effectiveness and ease of availability to the general public :

- I. Milk seems to be most ideal transport media for avulsed tooth.
- II. Patient own serum seems to be an ideal storage media for tooth autotransplant procedures .

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