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RESEARCH ARTICLE

APICAL VAPOUR LOCK EFFECT -PHENOMENON RELATED TO ENDODONTIC IRRIGATION– A REVIEW.

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Abstract

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Introduction:-

Complete debridement of the root canal system is a primary requirement for the successful root canal treatment[1]. Thus for optimum disinfection , a thorough cleaning and shaping is mandatory ; so the current concept in Endodontics is ' Files shape, irrigants clean'[2]. Even with the use of rotary instrumentation, the nickel-titanium instruments currently available only act on the central body of the canal, leaving canal fins, isthmi, and cul-de-sacs untouched after completion of the preparation. These areas might harbor tissue debris, microbes, and their by-products, which might prevent close adaptation of the obturation material and result in persistent periradicular inflammation[3,4].So the irrigants must be brought into direct contact with the entire canal wall surfaces for effective action, particularly for the apical portions of small root canals. Recently, concern has been expressed about the possible presence of gas bubbles in the apical part of the root canal that could block irrigant penetration and may affect effective debridement.This phenomenon is termed as'apical vapor lock'[5] (AVL). It is also called as Dead Water Zone.

Apical Vapour lock concept:

The debridement efficacy of an irrigation delivery/agitation system depends on how well the irrigant reaches the apical region, the uninstrumented zones, and creates a strong enough current to carry the debris out of the root canal coronally.[1,4-6] It is critically important to develop an irrigation protocol wherein the irrigant penetrates into all areas of the root canal, including the apical ramifications, isthmi, fins and deltas. It is difficult to do so . According to Chow (1983) 'For the irrigation solution to be mechanically effective in removing all the particles, it has to a) reach the apex, b) create a current, and c) carry the particles away..[1] Apical vapour lock effect is one of the major hindrances in achieving these objectives .

A root canal resembles and behaves like a close-ended channel as roots are surrounded by alveolar socket. Hence during cleaning and shaping there is a formation of an apical vapor lock effect wherein there is air entrapment by an advancing liquid front in closed-end microchannels which subsequently hinders the debridement of apical one third.[2,7] This has been described as the difficulty of dispersion and mixing of an irrigant in a confined space, whereas in an open canal system, this would not occur, and the irrigant would flow out of the apical foramen . The ability of a liquid to penetrate these closed-end channels is dependent on the contact angle of the liquid and the depth and size of the channel. These microchannels (root canals) will be flooded eventually with the fluids (irrigants) after a sufficient time period, which can extend from hours to days. Thus as such the vapour lock effect is not a permanent one[2,7]. However endodontics treatment is takes less time so endodontic irrigation is performed within a time frame of minutes instead of hours or days, air entrapment in the apical portion of the canal might preclude this region from contact or disinfection by the irrigant.

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The most commonly used irrigant i.e Sodium Hypochlorite causes dissolution of organic tissue of dentinal walls, which liberates carbon dioxide and ammonia. This forms micro gas bubbles in the apical portion of the root canal that coalesce into a apical vapour bubble and gets trapped in the apical region which quickly forms a column of gas into which further fluid penetration is impossible[2]. Extension of instruments into this vapor lock does not reduce or remove the gas bubble, just as it does not enable adequate flow of irrigant. Since there is no suitable replacement for NaOCl,as per the evidences available it is all the more imperative that the AVL problem be prevented and eliminated.

Effect of different irrigation techniques on AVL:
The apical vapor lock (dead water zone) is consistently formed during routine endodontic irrigation which impedes irrigant penetration till the working length, thereby leading to inefficient debridement. Hence, to eliminate this vapour lock, various techniques of iirrigation should be used along with the irrigant after cleaning and shaping of the root canal.

However, currently there is no universally accepted standard irrigation technique

Chow (1983), determined that traditional positive pressure irrigation had virtually no effect apical to the orifice of the irrigation needle in a closed root canal system. Exchange of fluids and debris displacement were minimal in this region. There are two apparently dilemmatic phenomena associated with conventional syringe needle delivery of irrigants. For effective debris debridement and smear layer removal it is desirable for the irrigants to be in direct contact with canal walls. Yet, it is difficult for these irrigants to reach the apical portions of the canals because of air entrapment, when the needle tips are placed too far away from the apical end of the canals. Conversely, if the needle tips are positioned too close to the apical foramen, there is an increased possibility of irrigant extrusion from the foramen that might result in severe iatrogenic damage to the periapical tissues.[8] Even use of side vented needles had no significant effect on AVL. According to previous Researches these vapour lock cannot be removed by conventional syringe irrigation.

Mechanical agitation techniques during irrigation with files, rotary brushes (eg Ruddle brush and canal brush), etc also have proved unsuccessful in dislodging AVL. Trying to ‘puncture’ it with an instrument or needle, which makes the space smaller, and increases the surface tension.[2]

Ultrasonics can effectively clean debris and bacteria from the root canal system, but cannot effectively get through the apical vapor lock.Sonics and Ultrasonics works on the principle of acoustic microstreaming and cavitation. The movement of fluids along cell membranes, which occurs as a result of the ultrasound energy creating mechanical pressure changes within the tissue is acoustic microstreaming . while cavitation refers to the formation and collapse of gas and vapor filled bubbles or cavities in the liquids or fluids. Thus, acoustic streaming and cavitation can only occur in a liquid phase, not in gases. Hence, once a sonic or ultrasonically activated tip leaves the irrigant and enters the apical vapor lock, acoustic microstreaming and/or cavitation becomes physically impossible[9] as apical vapour lock is column of gases.

Methods to eliminate/prevent avl:
It is importanat to eliminate the AVL to achieve the complete debridement of root canal system**:**

Achieve apical patency:
Establishing apical patency is leaving the apical foramen accessible, free from dentin chips, pulp fragments and other debris. It can be achieved with a small size file, which moves passively through the foramen[10]. This step during cleaning and shaping may be considered an important step in preventing AVL formation

Apical size of root canal and **Size of irrigating Needle tip**
Grossman recognized the need for adequate enlargement of the root canal to improve irrigation efficacy as early as in 1943[11].Larger the apical size of the root canal, lesser is the chance of AVL formation. However, over-enlargement of the canal comes with different disadvantages like reduction in radicular dentin thickness and subsequent weakening of the root structure, this should be kept in mind before deciding the apical size of root canal.

Size and Apical extent of needle tip :

The size of irrigating needle tip Commercially available needles of size like 27 G needle has an outer diameter of 0.41 mm (corresponds with ISO size # 40 endodontic instrument), 30 G and 31G needles have outer diameters of 0.31mm (size# 30) and 0.26mm (size # 25) respectively. The most preferred needle tip size is 27 gauge needle for routine endodontic procedures. In narrow curved canals, introduction of a syringe apically may be impossible. Flexible or NiTi tips are available that can negotiate curved canals more easily. Needles can be prebended in curved canals.

It is now proven that an irrigant can reach only 1-1.5 mm beyond the tip of the needle The tip must extend as close to working length as possible, taking care that there be no periapical extrusion of the irrigant[2].

Irrigant flow rate –

Some researchers suggest that exceeding a rate above 4 ml/ min does not improve apical clearance but does increase the risk of extrusion; therefore 1 ml increments over 15 seconds give maximum exchange and minimum risk[10,12]

Manual dynamic agitation –

The simplest and easiest method of tackling AVL is following instrumentation, the canal is filled with irrigant and the gutta percha master cone inserted to working length . It is then hand –activated and 'pumped' up and down in rapid 3 mm motions. This method, although cumbersome, eliminates the vapor lock because the space previously occupied by air is replaced by the root filling material, carrying with it a film of irrigant to the working length Several studies have demonstrated that manual-dynamic irrigation is significantly more effective than an automated-dynamic irrigation system and static irrigation.

Manual dynamic agitation succeeds possibly because of the following factors:

1. The selection of a guttapercha cone corresponding to the canal preparation size and taper so air in the apical third gets displaced when the guttapercha is inserted to working length.
2. Generation of higher intracanal pressure due to push-pull motion of a snugly fitting master cone , thereby carrying the irrigant to the "untouched" canal surfaces.
3. Generating more turbulence in the canal as frequency of this technique (3.3 Hz, 100 strokes per 30 seconds) is higher than that of automated-dynamic irrigation systems (1.6 Hz), d) It acts by physically displacing, folding, and cutting of fluid under ''viscously-dominated flow'' in the root canal system. It allows the irrigating solution to flow up and down along the cone, with the solution being displaced outward when the cone is inserted at length and flowing inward when it is removed. This enables better mixing of the fresh unreacted solution with the spent, reacted irrigant.[8,13]
4. Technique is easy ,simple and economically not expensive.

Pressure Alternation Techniques: -

Concomitant irrigant delivery and aspiration via the use of pressure alternation devices provide a plausible solution to this problem.

The RinsEndo irrigation system :

The RinsEndo irrigation system (RinsEndo, Co. Duerr- Dental, Bittigheim-Bissingen, Germany) irrigates the canal by using pressure-suction technology. The manufacturer of RinsEndo claims that the apical third of the canal might be effectively rinsed, with the cannula restricted to the coronal third of the root canal because of the pulsating nature of the fluid flow. It is composed of a handpiece, a cannula with a 7-mm-long exit aperture, and a syringe carrying irrigant. The handpiece is powered by a dental air compressor and has an irrigation speed of 6.2 ml/min.[8,14]With this system, 65 mL of a rinsing solution oscillating at a frequency of 1.6 Hz is drawn from an attached syringe and transported to the root canal via an adapted cannula. During the suction phase, the used solution and air are extracted from the root canal and automatically merged with fresh rinsing solution. The pressure-suction cycles change approximately 100 times per minute.

The EndovacSystem :

The system designed by Dr. G. John Schoeffel and has been introduced by Discus Dental Company. It has three components: The Master Delivery Tip, MacroCannula and MicroCannula. The Master Delivery Tip simultaneously delivers and evacuates the irrigant.Suction of irrigant from the chamber to coronal and middle segments of the canal is achieved by the MacroCannula. The MacroCannula or MicroCannula is connected via tubing to the high-speed suction of a dental unit. The Master Delivery Tip is connected to a syringe of irrigant and the evacuation hood is connected via tubing to the high-speed suction of a dental unit.[15] During irrigation, the delivery/evacuation tip delivers irrigant to the pulp chamber and siphons off the excess irrigant to prevent overflow. The cannula in the canal simultaneously exerts negative pressure that pulls irrigant from its fresh supply in the chamber, down the canal to the tip of the cannula, into the cannula, and out through the suction hose. Thus, a constant flow of fresh irrigant is being delivered by negative pressure to working length. Apical negative pressure has been shown to enable irrigants to reach the apical third and help overcome the issue of apical vapor lock.[16,17]

Endo Irrigator Plus (K Dent Dental System) is an irrigating system based on ACWIS (Activated continuous warm irrigation and evacuation system) concept. In this unit NaOCl is warmed upto 45°. This device creates positive and negative pressure inside the canal. Positive pressure irrigation with warm NaOCl cleans and disinfects up to the middle third, and removes all macro debris. All micro and nano debris from the apical third are removed by Negative pressure irrigation with warm NaOCl and area is cleaned and disinfected. Trials done under electronic microscope found that this device actually helps penetration of NaOCl into the lateral and accessories canals. Strong vacuum evacuation system prevents overextrusion of NaOCl. This irrigation system has also proved effective against AVL.[18,19]

Conclusion:-

1. AVL prevents complete debridement of the root canal system. Hence improper irrigation of apical third of root canals can lead to compromised endodontic outcomes, a clinician should try his best to prevent or eliminate the AVL.
2. The AVL and consideration for the patient's safety have always prevented the thorough cleaning of the apical third. It is critically important to determine which irrigation system will effectively clean this critical area of the pulp space concurrently giving due respect to its immediate neighbours. A meticulous disinfection protocol will go a long way in ensuring endodontic success.
3. Negative irrigation is although more superior to positive pressure irrigation as prevent periapical extrution of irrigant, provides better cleansing, has no vapor lock effect and provides adequate irrigant volume but still further research is warranted.

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