**Journal of Advanced Medical and Dental Sciences Research**

@Society of Scientific Research and Studies ***NLM ID:*** *101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Index Copernicus value = 85.10

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

# Review Article

## Endovac- Pressure Modulated Irrigation in Endodontics

Dr. Sunidhi Khuteta[1], Dr. Shahina Parvez[2], Dr. Manoj Agarwal[3], Dr. Rohit Khatri[4]

1. Post graduate Resident, Department of Conservative dentistry and Endodontics, RUHS College of Dental Sciences, Jaipur (Rajasthan)
2. Professor and Head, Department of Conservative dentistry and Endodontics, RUHS College of Dental Sciences, Jaipur (Rajasthan)
3. Associate Professor, Department of Conservative dentistry and Endodontics, RUHS College of Dental Sciences, Jaipur (Rajasthan)
4. Assistant Professor, Department of Conservative dentistry and Endodontics, RUHS College of Dental Sciences, Jaipur (Rajasthan)

***ABSTRACT:***

EndoVac (Apical negative pressure irrigation system) safely and predictably delivers irrigating solution to the apical terminus with penetration of irrigant into the anatomical complexities of root canal. In present article the available literature on EndoVac is reviewed from a MEDLINE database research. This article presents an overview of negative pressure irrigation and its safety, efficacy, efficiency and regenerative potential, removal of smear layer and debris, microbial reduction and assessment of post-operative pain after using negative pressure irrigation technique. Weather these parameters translate into a better clinical outcome remains to be seen.

**Key words**: EndoVac, Negative pressure irrigation, Macrocannula, Microcannula, Apical Vapor lock

**Received:** 12/09/2020 **Modified:** 18/10/2020 **Accepted:** 20/10/2020

**Corresponding Author**: Dr Shahina Parvez, Professor and Head, Department of Conservative Dentistry and Endodontics, RUHS College of Dental Sciences, Jaipur (Rajasthan)

**This article may be cited as**: Khuteta S, Parvez S, Agarwal M, Khatri R. Endovac- Pressure Modulated Irrigation in Endodontics. J Adv Med Dent Scie Res 2020;8(11):73-82.

### INTRODUCTION

The complete elimination of debris and smear layer from the root canal system is significantly challenging because of complex root canal morphology consisting of lateral canals, isthmus, fins and accessory canals.[1] This debris can consist of dentin shavings, toxins, residual pulp tissue, microorganisms, and biofilms.

Peters at al[2] and Schafer et al[3] compared microcomputed tomography scans before and after mechanical instrumentation and found that regardless of the instrument technique, 35% or more of the root canal surfaces remained uninstrumented. Therefore, chemical debridement via the use of an irrigant is a necessary adjunct to mechanical instrumentation for killing microbes, flushing debris and removing the smear layer from the canal system.[4,5,6]

For the endodontic irrigant to be mechanically effective it must reach the apical terminus, create a current along the root canal wall and have the ability to carry away debris, tissue and bacterial contaminants.[7] 5.25% Sodium hypochlorite is the only root canal irrigant that can completely remove biofilm from the root canal system and prevent microbial growth.[8,9,10]

Therefore, these objectives can be achieved by an effective delivery system which delivers irrigant to working length with sufficient flow and volume which is effective in debriding the canal system with inadvertent extrusion into periradicular tissues. Root canal irrigation systems can be divided into two categories - manual irrigation techniques and machine-assisted irrigation techniques as shown in Table-1.[11]

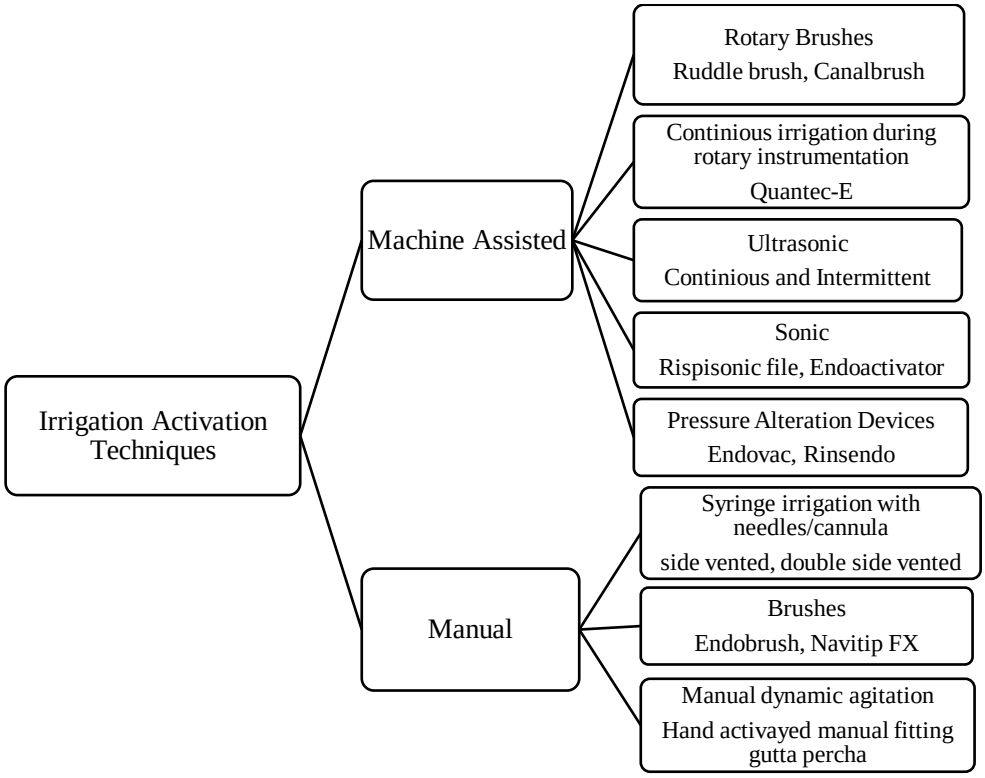



Table-1: Various irrigation techniques

Traditionally conventional needles (different sizes and tip designs) were used to deliver sodium hypochlorite from the barrel into the root canal system. But syringe irrigation has been employed in all the sodium hypochlorite accidents in history especially open ended needles,[12,13] resulting in post-operative pain and interappointment flare ups, discomfort, swelling, tissue damage, profuse damage both interstitially and through the tooth, necrosis, secondary infection and in few cases long term paraesthesia or scarring.[14,15] Therefore, its use should be restricted within the confines of the root canal system.

Major factor responsible for extrusion of irrigant with positive pressure irrigation is wedging of needle (Technique related factor) which would lead to entrapment of the flow apically to the needle tip without any route of escape towards the canal orifice which increases irrigant pressure at the apical foramen. While other factors like over instrumentation and perforation (Anatomy related factors) increases cross sectional area of the pathway connecting the root canal to the surrounding tissues, so resistance to irrigant extrusion is decreased. Another drawback of positive pressure irrigation is the apical stagnation or dead zone which allows for gas entrapment, created due to decomposition of the organic tissue by sodium hypochlorite. This physical phenomenon is called apical vapor lock making it difficult to adequately debride the canal's apical termination.[16]

Therefore, any root canal irrigation delivery system that minimizes the risk of extrusion of debris and irrigant into the periapical tissues and remove apical vapor lock would be of benefit to the clinician. Apical negative pressure (ANP) was developed to improve irrigant delivery throughout the root canal.

Negative pressure refers to a situation in which an enclosed volume has lower pressure than its surroundings. In medical quarantine situations where an isolation room will have negative pressure so the outflow of contaminated air is through an opened door or window. This prevents microorganisms from escaping and makes it safer for patients and medical personnel.[17]

In the same way in the root canal system, apical negative-pressure systems for irrigation have the ability to suction, thereby drawing and delivering the irrigant passively to the apex and positively addressing the problem of irrigation penetration past the apex into the periapical tissue which may result in treatment complications.[18]

A new apical negative-pressure irrigation system called EndoVac (Discus Dental, Culver city, CA) is designed by Dr G.John Schoeffel in 2007 has been developed as a means to irrigate and remove debris to the apical constriction without forcing solution out the apex into the periapical tissue.[19]EndoVac system comprises four main components: (Figure-1)

1. **The multiport adapter (MPA):** It plugs directly into Hi-Vac and serves as a caddy for the EndoVac tubing, and other components are easily removed and reattached to the Hi-Vac system for maximum portability between operatory.

2. **The master delivery tip (MDT):** The MDT which is a 22 Gauge needle (ISO 70) is plugged directly into

the MPA and provide a constant flow of the irrigating solution into the pulp chamber without the risk of overflow by suctioning with the tip fixed around it. It is used to remove gross debris generated during coronal flaring and after each instrument change.

3. **The Macrocannula** is used to remove coarse debris from the root canal systems after the completion of instrumentation. The macrocannula is made of plastic with an open end of 0.55 mm and an internal diameter of 0.35mm and a 0.02 taper and aims to remove gross debris from the coronal and middle third of the root canal. The macrocannula and the MDT are used simultaneously while moving the macrocannula up and down each canal. It is designed for single use and should be discarded after each treatment.

4. **The Microcannula** is a 28-gauge needle (0.32 mm) made of stainless steel with 12 laser-drilled, microscopic evacuation holes (disposed in 4 rows of 3)—each less than 100 µm in size—laterally positioned within the last 0.7 mm of the needle. The first hole in the row is located 0.37 mm from the tip while the distance between holes is 0.1 mm. It is designed for single use and should be discarded after each treatment.

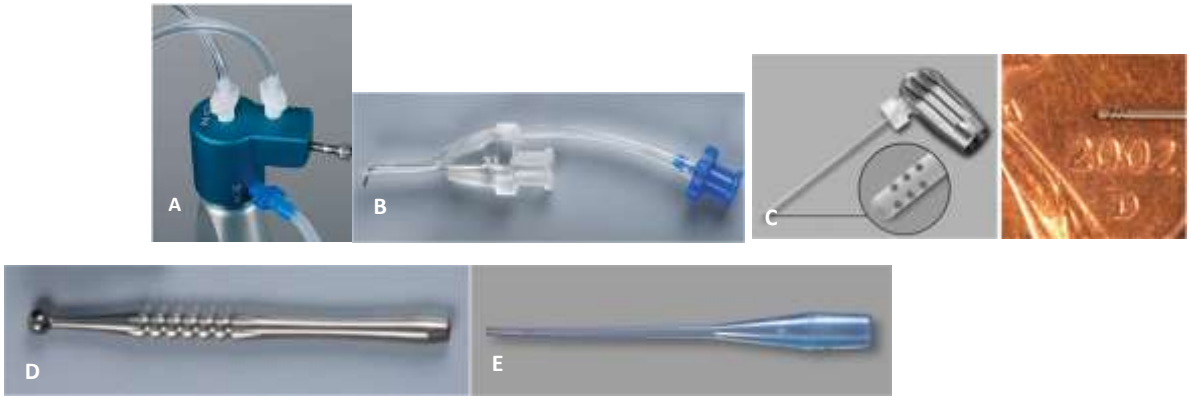



**FIGURE-1 - EndoVac components: (A) Multi Portadaptor ;(B) Master Delivery tip ;(C) The ISO size of 0.32-mm-external-diameter stainless-steel microcannula of zero taper has four sets of three laser-cut, laterally positioned offset holes adjacent to its closed end, 100 µ in diameter and spaced 100 µ apart; (D) Autoclavable handpiece for Macrocannula ; (E)Macrocannula**

## CLINICAL TECHNIQUE

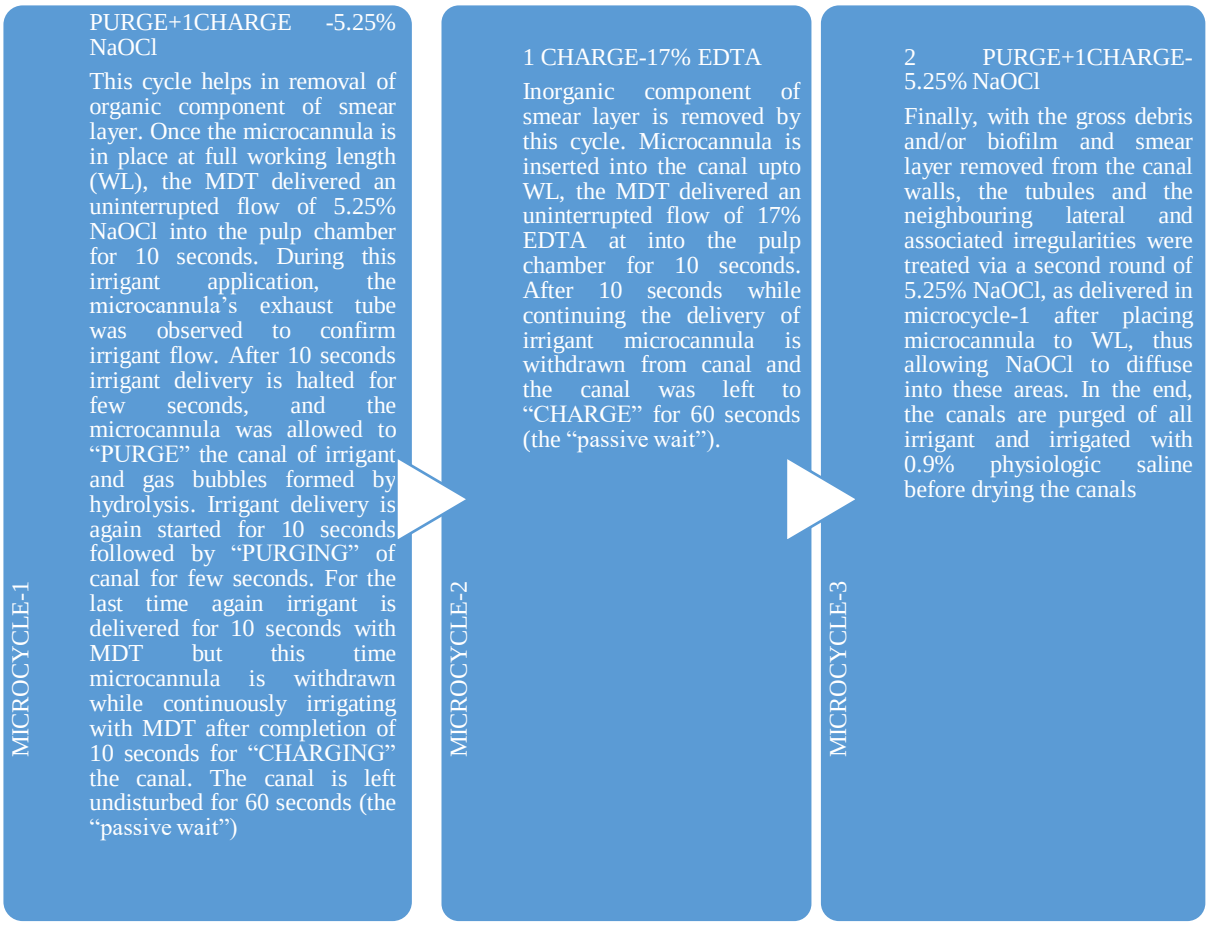
After the access cavity preparation, pulp chamber is constantly delivered/evacuated with 5.25% NaOCl solution with Master Delivery Tip of EndoVac keeping the chamber full of irrigant at all times. During the entire instrumentation process, the MDT is used to replenish 1 ml of 5.25% NaOCl into the pulp chamber before and after every instrument change. While delivering irrigant with MDT, it is always placed against axial wall and never on orifice to prevent extrusion of NaOCl. Once instrumentation is completed, the canal is macroirrigated with microcannula and microirrigated with microcannula.

### MACROIRRIGATION

A macrocannula is used to evacuate the gross debris from the root canal cavity after instrumentation. It is used for 30 seconds in canal after instrumentation by rapidly moving it from a point where it stopped its apical progression to just below the pulpal floor as 5.25% NaOCl is passively delivered via the MDT. Current flow is constantly monitored through the Macro's transparent polypropylene wall to ensure blockage has not occurred. After 30 seconds of rapid irrigant exchange, the canal is left "CHARGED" with NaOCl by quickly withdrawing the macrocannula from the canal while continuing to deliver 5.25% NaOCl via the MDT. The canal is left undisturbed for 60 seconds (the "passive wait").

### MICROIRRIGATION

Micro irrigation begins immediately following the macro irrigation's passive wait.
Three irrigation "microcycles" consisting of irrigant in sequence - 5.25% NaOCl, 17% EDTA, and 5.25% NaOCl comprise microirrigation.




The EndoVac's efficacy is based on its ability to create negative pressure inside the root canal system. It creates negative pressure from −30 to −260mm Hg throughout the root canal system from coronal part to apically till major diameter.[20] This allows irrigating solution to be delivered safely and effectively across canal irregularities. Furthermore, this constant irrigant exchange with adequate replenishment allows the establishment of a diffusion gradient whereby hyper concentrated solutions like 5.25% NaOCl diffuse into dead-end spaces.[21]

## REVIEW OF LITERATURE

### Safety of EndoVac

EndoVac has shown significantly less frequency of extrusion of NaOCl as compared with Conventional needle irrigation (side vented or tip vented needle.[22,23] Mitchell also showed that as apical size is increased the risk of irrigant extrusion also increases when irrigating with needle but the risk remains constant if irrigation is performed with EndoVac regardless of apical preparation size.[24]

Desai and Himel[25] demonstrated that the EV (both macro and micro cannula) failed to extrude any irrigant and debris from a tooth, while all Positive pressure delivery systems (Ultrasonics, Rinsendo and needle irrigation) did extrude irrigant. Endoactivator has shown more extrusion of irrigating solution than EV but the result is insignificant[18] and significant in some studies. Yost et al[26] and Azim et al[27] evaluated that when treating teeth with resorption, perforation defects, or immature roots with open apices the apical control of irrigants is achieved better with EndoVac than PIPS and XP Endo finisher.

### Penetration

The initial study which evaluated EndoVac's ability to introduce the irrigating solution up to the working length and canal irregularities was conducted by de Gregorio et al. which provided information about the penetration up to working length and the ability of the irrigant to be moved into the artificial lateral canals.[28] Regarding the penetration of irrigant into anatomical complexities of canal, it is designed primarily to safely place voluminous amount of irrigant to the canal's working length and not as an activation mechanism, but it was not as effective at filling the lateral canals as PUI. However, this limitation can be balanced by the diffusion effect described by Pashley et al.[29]

Table 2- Important studies related to safety of Endovac

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| Pranav Desai and Van Himel | 2009 | Endovac, Endoactivator and Conventional needle irrigation | Less extrusion in case of Endovac and Endoactivator |
| Mitchell et al | 2010 | Endovac and 27 Gauge needle | Less extrusion risk using Endovac |
| Mitchell et al | 2011 | Endovac, Endoactivator, Micro mega 1500, Passive ultrasonic irrigation, Syringe irrigation | Frequency of extrusion was less with Endovac than MicroMega and Syringe irrigation |
| Malentacca et al | 2012 | Endovac,Piezo flow used in injection mode and aspiration mode and Side vented needle | Endovac was safest but only by a slight margin compared with ultrasonic aspiration mode |
| Gupta et al | 2014 | Endovac and Conventional needle irrigation | Conventional needle irrigation had higher debris and irrigant extrusion than EndoVAc |
| Kartas et al | 2014 | Endovac, Vibringe, SAF, Passive ultrasonic irrigation and conventional needle irrigation | No significant difference Endovac, Vibringe and Conventional needle irrigation group in extrusion of debris |
| Charara et al | 2015 | Endovac, Gentle Wave and Open ended 30 Gauge needle | Irrigation with Endovac and Gentle wave is not associated with extrusion of irrigant |
| Yost et al | 2015 | Endovac, Endoactivator, Max-i-Probe, PIPS | Endovac showed less extrusion of irrigant |
| Azim et al | 2017 | Endovac, ENdoactivator, PIPS, XP Endo Finisher and 30 Gauge notched needle | Irrigant extrusion was unavoidable unless Endovac is used |
| Ribeiro et al | 2018 | Endovc and Conventional needle irrigation | Endovac extruded less debris |
| Akcay et al | 2019 | Endovac, Canal Cleanmax, SonicMax, RinsEndo, Passive ultrasonic irrigation and Needle irrigation | Endovac and CCMax showed no apical extrusion |

The instrumentation of canal till apical size ISO #40 increases the microcannula's ability to produce adequate apical negative pressure to resolve the physical barrier problem, described in a "stagnation zone" or the "vapor lock".[30] Goode et al. in 2013 demonstrated that ultrasonic activation could not effectively clean debris from a multiplanar canal; but the EndoVac produced significantly better debris removal than PP, manual dynamic, sonic, and ultrasonic activation.[20]

Cohenca's evaluated different irrigation systems in oval canals: EndoVac, positive pressure, and self-adjusting file (SAF) system. Results again confirmed the advantages of EndoVac, which delivered a full and constant irrigation at WL, showing significant differences compared to the other two systems.[31]

Munoz and Camacho-Cuadra evaluated the irrigant penetration in-vivo using a radiopaque contrast solution in mesial curved canals of mandibular molars. Because of the advantage of flexible microcannula which can be placed up to the working length even in curved canals, it showed a statistically significant difference in the irrigation at full canal length in comparison with PP and similar results to PUI.[32]

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| De Gregorio | 2010 | Efficacy of Endovac, Endoactivator, Passive ultrasonic activation (PUI), F file on the penetration of sodium hypochlorite | Endovac showed better penetration till working length but PUI showed more penetration in lateral canals |
| Munoz et al | 2012 | PUI, Endovac and conventional needle irrigation | Endovac and PUI more effective in delivering irrigant to working length |
| De Gregorio | 2012 | Endovac, SAF, Positive pressure irrigation | Endovac capable of irrigating consistently to full working length |
| Spoorthy et al | 2013 | Endovac, Passive ultrasonic irrigation (PUI) and combination of Endovac + PUI | Combination of Endovac + PUI achieved better penetration upto working length and lateral canals |

Table 3- Important studied related to penetration of irrigant with Endovac

**Debridement**

Traditionally, to enhance debridement, increase of the diameter and taper apical preparation has been proposed; however, the EndoVac's safe delivery design enables abundant and safe irrigant delivery when the apical preparation is as small as a #35 ISO.[25] Siu and Baumgartner[33] achieved better debridement and less Accumulated Hard Tissue Debris (AHTD) in the very last millimeters when using Apical negative pressure (ANP) than Positive pressure(PP) group. [34,35] EV removed more debris from root canals at 1.5 and 3.5mm from apex as compared to Max i Probe and NaviTips.[36] According to Susin et al, PP and ANP showed similar results at coronal thirds;[37] these can be explained as an effect at the level where the tip needle was placed, in concordance with the results obtained by Boutsioukis et al.[38] using computational fluid dynamics (CFD), as higher stress was observed on dentinal walls, which could be influenced by the level, depth, and orientation of the tip needle. In closed systems, debridement by PP is adversely affected by the presence of apical tissues. Parente et al.[39] showed that ANP is not affected by a closed system, while MDA had poor results in the same clinical conditions. ANP also achieved better cleaning at apical third of root canals in less exposure time than required with PP irrigation.[40]

Howard et al.[41] and Jiang et al.[42] obtained different results than the previously discussed studies. They found no significant differences between ANP, PP, MDA while CUI showed better debridement than ANP. This can be because of the high flow rate (15ml/min and 6ml/min respectively) used during the CUI irrigation in their study. High flow rates (>1ml/min) are associated with higher apical pressure (Greater than Central Venous pressure-5.88mm Hg) resulting in inadvertent extrusion of irrigating solution past the apex.[43]

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| Nielsen and Baumgartner | 2007 | Endovac and conventional technique | Endovac showed better debridement |
| Siu and Baumgartner | 2010 | Debridement efficacy of Endovac and conventional needle root canal irrigation | Better debridement with Endovac 1mm from working length |
| Parente et al | 2010 | Debridement in open and closed system | Endovac overcomes fluid dynamics challenges in closed canal systems |
| Susin et al | 2010 | Canal and isthmus debridement efficacies of Endovac and Manual dynamic irrigation | Endovac removed more debris |
| Howard et al | 2011 | Debris removal between Endovac, Pieze flow, needle irrigation | No significant difference in canal and isthmus cleanliness |
| Jiang et al | 2012 | Endovac, Continious ultrasonic irrigation(CUI), safety irrigator system, Manual dynamic agitation, Conventional needle irrigation | CUI was more effective than Endovac |
| Jee Yoo et al | 2013 | Endovac, Syringe irrigation, Ultrasonic activation, VPro Stream Clean irrigation | Endovac showed favourable debridement of isthmus |
| Thomas et al | 2014 | Endovac, Passive Ultrasonic irrigation and Conventional needle irrigation | Endovac showed clean canal isthmus |
| Versiani et al | 2015 | Removal of Accumulated of Hard tissue debris (AHTD) by Endovac and conventional needle irrigation | Endovac resulted in lower levels of AHTD |

Table 4 – Important studies related to debridement efficacy of Endoavc

**Smear Layer Removal**

Effectiveness of ANP is based on a controlled and deeper penetration of the irrigant solutions with adequate replenishment. EndoVac is more effective in removing smear layer from apical third than Endoactivator, Er:YAG Laser and needle irrigation. This can be attributed to the hydrodynamic and vigorous intracanal agitation which helps in overcoming apical vapor lock when the tip placed to the apex.[44] EndoVac is more effective in producing clean dentinal surface than PUI and MDA due to the advantage of placing microcannula to the WL which suctions the irrigant and bubbles in sufficient volume and provide portal of exit for smear layer and debris through orifices of micrcannula.[45] Also due to negative pressure the direction of fluid flow is from coronal to apical part with greater turbulence than PP irrigation resulting in better smear layer removal.[46]

Sealer penetration inside root canal is inversely proportional to the presence of smear layer. Therefore, EndoVac is better and superior in terms of depth and penetration of sealer in comparison to Endoactivator and Navi tip. [47]

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| Abarajithan et al | 2011 | Smear layer removal between Endovac and conventional technique | Endovac showed better results |
| Saber et al | 2011 | Endovac, Passive ultrasonic irrigation(PUI) and manual dynamic agitation(MDA) | Endovac and MDA better in smear layer removal than PUI |
| Suman et al | 2017 | Endovac, Endoactivator and Er:YAg laser | Endovac significantly better |
| Bharti et al | 2018 | Endovac, Endoactivator, Navitip on lateral depth and percentage of sealer penetration | Endovac showed more sealer penetration |

Table 5- Important studies related to smear layer removal by Endovac

**Antimicrobial Effect**

EndoVac was found effective in reduction of E. faecalis as CNI.[48,49] In another study Pawar et al[50] found no significant differences in reduction of bacteria between ANP and traditional irrigation. This is because "The original Endovac protocol" recommends the use of 5.25 % NaOCl while they used 0.5 % NaOCl in their study. This could be the reason for the absence of significant differences in antimicrobial action between Endovac irrigation and traditional irrigation.

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| Hockett et al | 2008 | E.faecalis population in tapered and non-tapered preparation after positive and negative pressure irrigation | Endovac had significant better microbial control |
| Townsend and Maki | 2009 | Mechanical removal of E.faecalis by Endovac, EndoActivator, F File, Ultrasonic irrigation, Sonic irrigation and needle irrigation | In a plastic stimulated canal, Ultrasonic agitation was more effective than needle irrigation and EndoVac |
| Brito et al | 2009 | E.faecalis populations after Endovac, EndoActivator and needle irrigation | No antibacterial superiority |
| Nestor Cohenca et al | 2010 | Antibacterial efficacy of Endovac and conventional technique | Endovac showed promising results |
| Miller and Baumgartner | 2010 | Antimicrobial efficacy of EndoVac and needle irrigation | Fewer cfu/mg when using Endovac but no significant difference |
| Pawar et al | 2012 | Antimicrobial efficacy of Endovac, Ultrasonic irrigation and Conventional technique | No significant difference |
| Hafiz and Abdelwahed | 2019 | Reduction of E.faecalis after Endovac and needle irrigation | Endovac was effective in reduction of E.faecalis |

Table 6- Important studies related to microbial efficacy by Endovac

**Regeneration and Revascularisation**

Negative pressure irrigation also fulfills the functions of recruiting undifferentiated mesenchymal cells from the apical region and creates a scaffold, fundamental for the induction of tissue neoformation. This is advantageous in treating teeth with resorption, perforation, defects, or immature roots with open apices.[53] Also, in such cases the apical control of irrigant is paramount for survival and differentiation of stem cells of apical papilla and to prevent aggression of periapical tissues caused by 5.25% sodium hypochlorite extrusion, EndoVac is suggested for irrigation.[26,51]

Pucinelli et al.[52] observed a significantly lower number of osteoclasts in the negative pressure group. Apical negative pressure irrigation also presented satisfactory results in reducing the bacterial content of root canals similarly to apical positive pressure irrigation (conventional irrigation) associated with the use of a triantibiotic intracanal dressing. Thus EndoVac can reduce potential biologic and clinical complications of triple antibiotic paste- the development of resistant bacterial strains, allergic reaction to the intracanal dressing and discolouration of tooth.[57]

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| Cohenca et al | 2010 | Endovac versus apical positive pressure irrigation plus triple antibiotic intracanal dressing on root canal disinfection | Similar bacterial reduction in both groups |
| Da Silva et al | 2010 | Revascularisation and periapical repair after Endovac and conventional irrigation with triple antibiotic paste | After use of Endovac intracanal disinfectants might not be ready |
| Pucinelli et al | 2017 | Endovac with conventional irrigationin immature teeth | Endovac shows better biological result and more advanced repair processin immature teeth with apical periodontitis |
| Da Silva et al | 2020 | Mineralizing potential of Endovac and conventional needle irrigation | Endovac shows mineralizing potential in immature teeth with apical periodontitis |

Table 7- Important studies related to regenerative potential of Endovac

| AUTHOR | YEAR | STUDY | RESULT |
|---|---|---|---|
| Gondim et al | 2010 | Post operative pain after application of two different irrigation devices | Less pain with Endovac |
| Al Nahlawi et al | 2016 | Effect of Endovac and cryotherapy on post operative pain | Endovac reduced post operative pain after 6 hours of treatment |
| Topcouoglu et al | 2018 | Effect of Endovac and conventional needle irrigation on post operative pain in mandibular molar | Apical positive pressure irrigation caused greater post operative pain as compared to Endovac |

Table 8- Important studies related to reduction in post operative pain by Endovac

**Post-operative Pain**

The first clinical study on the effect of EndoVac on post-operative pain in single rooted teeth (Incisor and canine) with asymptomatic irreversible pulpitis was conducted by Gondim et al.[54] He reported that the pain experience and analgesic intake with the negative apical pressure was significantly lower during 0-4 and 4-24 hour intervals after treatment in comparison to conventional needle irrigation. Al-Nahlawi et al.[55] revealed the effects of intracanal cryotherapy and negative irrigation technique (EndoVac System) on post endodontic pain after vital single visit endodontic treatment According to the results of this significant study, intracanal cryotherapy along with negative pressure irrigation system resulted in elimination of post endodontic pain clinically.

Another randomized control trial in mandibular molar performed by Topcuoglu et al[56] with total participants of 116 suggested that positive pressure irrigation caused greater postoperative pain at 6,24 and 48 hours as compared with apical negative pressure irrigation system.

**DISCUSSION**

Apical negative pressure system, Endovac irrigates the root canal system effectively to the fullest of the working length.[28,31] This is due to the design of the microcannula, which eliminates the vapor lock effect.[30] However, Endovac is only a method of delivering the irrigant in the canal and not activating. Malentacca et al proved that EndoVac produced adequate diffusion of NaOCl into adjacent lateral canals without any danger of extrusion conversely, it also proved that ultrasonic activation via passive, continuous positive, always caused some apical diffusion or extrusion in addition to lateral movement.[21]

The significant reduction in post-operative pain,[56] better debridement and smear layer removal,[44,35] reduced microbial growth and more regeneration with negative pressure irrigation can be attributed to inevitable extrusion of irrigating solution and debris into the periapical area by omnidirectional aspiration and negative pressure in the canal by microcannula.[53,48] Placing microcannula till the apex helps in better debridement, cleanliness and removal of smear layer by elimination vapor lock and dead water zone from root canal system. It gives the advantage of disinfection of canal without resorting to calcium hydroxide thereby completing treatment in single visit with similar microbial reduction without compromising the outcome. Microcannulas can also aspirate both purulent exudate and inflammatory exudate from apical area. Considering this, the negative apical pressure has a slight advantage over the conventional methods in in vivo researches.[57]

An apical enlargement to 40/04 will allow tooth preservation and maximum volume of irrigation at the apical third when using Endovac .[58] Though desirable results are achieved with Endovac but there is insufficient data about vaccum required and volume of irrigant passed through macrcannula and microcannula are still not standardised. More well-designed prospective randomized controlled trials are

needed to determine the effect of negative pressure on clinical outcome.

## CONCLUSION

The negative pressure created by Endovac permits evacuation of apical exudate and is safe as it draws irrigants to the source via suction—down the canal and simultaneously away from the apical tissue in abundant quantities. When the proper irrigating agents are delivered safely to the full extent of the root canal terminus, thereby removing most of organic tissue and microbial contaminants from the anatomically complex areas, success in endodontic treatment may be taken to levels never seen before.

## REFERENCES


1. Howard, R.K., Kirkpatrick, T.C., Rutledge, R.E. & Yaccino, J.M. (2011) Comparison of debris removal with three different irrigation techniques. Journal of Endodontics, 37 (9), 1301–1305
2. Peters OA, Laib A, Rüegsegger P, Barbakow F (2000c) Three dimensional analysis of root canal geometry using high resolution computed tomography. Journal of Dental Research 79, 1405–9.
3. Schäfer E, Diez C, Hoppe W, Tepel J. Roentgenographic investigation of frequency and degree of canal curvatures in human permanent teeth. J Endod 2002: 28: 211–216.
4. Parente, J.M., Loushine, R.J., Susin, L. et al. (2010) Root canal debridement using manual dynamic agitation or the EndoVac for final irrigation in a closed system and an open system. International Endodontic Journal, 43 (11), 1001–1012.
5. Young GR, Parashos P, Messer HH. The principles of techniques for cleaning root canals. Aust Dent J 2007;52(Supplement):S52–63.
6. Stavileci M, Hoxha V, Görduysus Ö, Tatar I, Laperre K, Hostens J et al. Evaluation of root canal preparation using rotary system and hand instruments assessed by micro-computed tomography. Med Sci Monit Basic Res. 2015 Jun;21:123-30
7. Chow, T.W. (1983) Mechanical effectiveness of root canal irrigation. Journal of Endodontics, 9 (11), 475–479
8. M. S. Clegg, F. J. Vertucci, C. Walker, M. Belanger, and L. R. Britto, “The effect of exposure to irrigant solutions on apical dentin biofilms in vitro,” Journal of Endodontics, vol. 32, no. 5, pp. 434–437, 2006.
9. Yesilsoy C, Whitaker E, Cleveland D, Phillips E, Trope M (1995) Antimicrobial and toxic effects of established and potential root canal irrigants. Journal of Endodontics 21, 513-5
10. Harrison JW. Irrigation of the root canal system. Dental Clinics of North America. 1984 Oct;28(4):797-808.
11. Gu LS, Kim JR, Ling J, Choi KK, Pashley DH, Tay FR. Review of contemporary irrigant agitation techniques and devices. J Endod. 2009;35(6):791-804
12. Hulsmann M, Hahn W (2000) Complications during root canal irrigation – literature review and case reports. International Endodontic Journal 33, 186–93
13. Boutsioukis C, Verhaagen B, Versluis M, Kastrinakis E, Wes-selink PR, van der Sluis LW. Evaluation of irrigant flow in the root canal using different needle types by an unsteady computa-tional fluid dynamics model. J Endod. 2010;36(5):875-9.
14. Romualdo PC, de Oliveira KMH, Nemezio MA, et al. Does apical negative pressure prevent the apical extrusion of debris and irrigant compared with conventional irrigation? A systematic review and meta-analysis. *Aust Endod J*. 2017;43(3):129-137.
15. Mehdipour O, Kleier DJ, Averbach RE. Anatomy of sodium hypochlorite accidents. *Compend Contin Educ Dent*. 2007;28(10):544-550.
16. Boutsioukis C, Lambrianidis T, Kastrinakis E. Irrigant flow within a prepared root canal using various flow rates: a Computational Fluid Dynamics study. Int Endod J. 2009 Feb;42(2):144-55.
17. Glassman G, Charara K (2015) Apical negative pressure: safety, efficacy and efficiency. In: Basrani B. ed. Endodontic irrigation: Chemical disinfection of the root canal system. New York, NY, USA: Springer. pp. 157 - 71.
18. Mitchell RP, Baumgartner JC, Sedgley CM. Apical extrusion of sodium hypochlorite using different root canal irrigation systems. J Endod. 2011;37(12):1677-1681.
19. G. John Schoeffel. The EndoVac Method of Endodontic Irrigation – safety first. Dentistry Today. october 2007
20. Goode, N., Khan, S., Eid, A.A. et al. (2013) Wall shear stress effects of different endodontic irrigation techniques and systems. Journal of Dentistry, 41 (7), 636–641.
21. Malentacca, A., Uccioli, U., Zangari, D., Lajolo, C. & Fabiani, C. (2012) Efficacy and safety of various active irrigation devices when used with either positive or negative pressure: an invitro study. Journal of Endodontics, 38 (12), 1622–1626.
22. Venumbaka NR, Baskaran P, Mungara J, Chenchugopal M, Elangovan A, Vijayakumar P. Comparative Evaluation of the Efficacy of EndoVac and Conventional Irrigating Systems in Primary Molars - An in Vitro Study. J Clin Pediatr Dent. 2018;42(2):140-145.
23. Alkahtani, A., Al Khudhairi, T.D. & Anil, S. A comparative study of the debridement efficacy and apical extrusion of dynamic and passive root canal irrigation systems. BMC Oral Health 14, 12 (2014).
24. Mitchell, R.P.,Yang,S.E.&Baumgartner, J.C.(2010) Comparison of apical extrusion of NaOCl using the EndoVac or needle irrigation of root canals. Journal of Endodontics, 36 (2), 338–341.
25. Desai, P. & Himel, V. (2009) Comparative safety of various intracanal irrigation systems. Journal of Endodontics, 35 (4), 545–549
26. Yost RA, Bergeron BE, Kirkpatrick TC, Roberts MD, Roberts HW, Himel VT, Sabey KA. Evaluation of 4 Different Irrigating Systems for Apical Extrusion of Sodium Hypochlorite. J Endod. 2015 Sep;41(9):1530-4.
27. Azim AA, Aksel H, Margaret Jefferson M, Huang GT. Comparison of sodium hypochlorite extrusion by five irrigation systems using an artificial root socket model and a quantitative chemical method. Clin Oral Investig. 2018;22(2):1055-1061
28. deGregorio,C.,Estevez,R.,Cisneros,R.,Paranjpe, A. & Cohenca, N. (2010) Efficacy of different irrigation and activation systems on the penetration of sodium hypochlorite into simulated lateral canals and upto working length: an in vitro study. Journal of Endodontics, 36 (7), 1216–1221.
29. Pashley, E.L., Birdsong, N.L., Bowman, K. & Pashley, D.H. (1985) Cytotoxic effects of NaOCl on vital tissue. Journal of Endodontics, 11 (12), 525–528.
30. Tay FR, Gu LS, Schoeffel GJ, Wimmer C, Susin L, Zhang K, Arun SN, Kim J, Looney SW, Pashley DH. Effect of vapor lock on root canal debridement by using a side-vented needle for positive-pressure irrigant delivery. J Endod. 2010 Apr;36(4):745-50
31. de Gregorio, C., Paranjpe, A., Garcia, A. et al. (2012) Efficacy of irrigation systems on penetration of sodium hypochlorite to working length and to simulated uninstrumented areas in oval shaped root canals. International Endodontic Journal, 45 (5), 475–481

32. Munoz, H.R. & Camacho-Cuadra, K. (2012) In vivo efficacy of three different endodontic irrigation systems for irrigant delivery to working length of mesial canals of mandibular molars. Journal of Endodontics, 38 (4), 445–448.
33. Siu, C. & Baumgartner, J.C. (2010) Comparison of the debridement efficacy of the EndoVac irrigation system and conventional needle root canal irrigation in vivo. Journal of Endodontics, 36 (11), 1782–1785
34. Versiani MA, Alves FR, Andrade-Junior CV, et al. Micro-CT evaluation of the efficacy of hard-tissue removal from the root canal and isthmus area by positive and negative pressure irrigation systems. Int Endod J 2016;49:1079–87
35. Nielsen, B.A. & Craig Baumgartner, J. (2007) Comparison of the EndoVac system to needle irrigation of root canals. Journal of Endodontics, 33 (5), 611–615
36. Saini M, Kumari M, Taneja S. Comparative evaluation of the efficacy of three different irrigation devices in removal of debris from root canal at two different levels: An in vitro study. J Conserv Dent 2013;16:509-13
37. Susin L, Liu Y, Yoon JC, Parente JM, Loushine RJ, Ricucci D, Bryan T, Weller RN, Pashley DH, Tay FR. Canal and isthmus debridement efficacies of two irrigant agitation techniques in a closed system. Int Endod J. 2010 Dec;43(12):1077-90.
38. Boutsioukis, C., Verhaagen, B., Versluis, M., Kastrinakis, E., Wesselink, P.R. & van der Sluis, L.W. (2010) Evaluation of irrigant flow in the root canal using different needle types by an unsteady computational fluid dynamics model. Journal of Endodontics, 36 (5), 875–879
39. Parente, J.M., Loushine, R.J., Susin, L. et al. (2010) Root canal debridement using manual dynamic agitation or the EndoVac for final irrigation in a closed system and an open system. International Endodontic Journal, 43 (11), 1001–1012. 33.
40. Heilborn, C., Reynolds, K., Johnson, J.D. & Cohenca, N. (2010) Cleaning efficacy of an apical negative-pressure irrigation system at different exposure times. Quintessence International, 41 (9), 759–767.
41. Howard, R.K., Kirkpatrick, T.C., Rutledge, R.E. & Yaccino, J.M. (2011) Comparison of debris removal with three different irrigation techniques. Journalof Endodontics, 37 (9), 1301–1305
42. Jiang LM, Lak B, Eijsvogels LM, Wesselink P, van der Sluis LW. Comparison of the cleaning efficacy of different final irrigation techniques. J Endod. 2012 Jun;38(6):838-41.
43. Khan S, Niu LN, Eid AA, et al. Periapical pressures developed by nonbinding irrigation needles at various irrigation delivery rates. J Endod. 2013;39(4):529-533.
44. Suman S, Verma P, Prakash-Tikku A, Bains R, Kumar-Shakya V. A Comparative Evaluation of Smear Layer Removal Using Apical Negative Pressure (EndoVac), Sonic Irrigation (EndoActivator) and Er:YAG laser - An *In vitro* SEM Study. *J Clin Exp Dent*. 2017;9(8):e981-e987
45. Saber Sel-D, Hashem AA. Efficacy of different final irrigation activation techniques on smear layer removal. J Endod. 2011;37(9):1272-1275
46. Abarajithan M, Dham S, Velmurugan N, Valerian-Albuquerque D, Ballal S, Senthilkumar H. Comparison of Endovac irrigation system with conventional irrigation for removal of intracanal smear layer: an in vitro study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112(3):407-411
47. Bharti R, Tikku AP, Chandra A, Shakya VK, Yadav S. Depth and percentage of resin-based sealer penetration inside the dentinal tubules using EndoVac, EndoActivator, Navi tip FX irrigation system: A confocal laser scanning microscope study. J Conserv Dent. 2018;21(2):216-220.
48. Hockett JL, Dommisch JK, Johnson JD, Cohenca N. Antimi-crobial efficacy of two irrigation techniques in tapered and nonta-pered canal preparations: an in vitro study. J Endod. 2008;34(11):1374-77
49. Miller, T.A. & Baumgartner, J.C. (2010) Comparison of the antimicrobial efficacy of irrigation using the EndoVac to endodontic needle delivery. Journal of Endodontics, 36 (3), 509–511.
50. Pawar, R., Alqaied, A., Safavi, K., Boyko, J. & Kaufman, B. (2012) Influence of an apical negative pressure irrigation system on bacterial elimination during endodontic therapy: a prospective randomized clinical study. Journal of Endodontics, 38 (9), 1177–1181.
51. Silva LABD, Linhares ML, Silva RABD, et al. Negative Pressure Irrigation Presents Mineralizing Potential in Dogs' Immature Teeth with Periapical Lesion. Braz Dent J. 2020;31(1):37-43
52. Pucinelli CM, Silva LABD, Cohenca N, Romualdo PC, Silva RABD, Consolaro A, Queiroz AM, Nelson P Filho. Apical Negative Pressure irrigation presents tissue compatibility in immature teeth. J Appl Oral Sci. 2017 Nov-Dec;25(6):612-619.
53. Cohenca, N., Heilborn, C., Johnson, J.D., Flores, D.S., Ito, I.Y. & da Silva, L.A. (2010) Apical negative pressure irrigation versus conventional irrigation plus triantibiotic intracanal dressing on root canal disinfection in dog teeth. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 109 (1), e42–e46.
54. Gondim, E. Jr., Setzer, F.C., Dos Carmo, C.B. & Kim, S. (2010) Postoperative pain after the application of two different irrigation devices in a prospective randomized clinical trial. Journal of Endodontics, 36 (8), 1295–1301
55. Al-Nahlawi T, Hatab TA, Alrazak MA, Al-Abdullah A. Effect of Intracanal Cryotherapy and Negative Irrigation Technique on Postendodontic Pain. J Contemp Dent Pract. 2016 Dec 1;17(12):990-996
56. Topçuoğlu HS, Topçuoğlu G, Arslan H. The Effect of Apical Positive and Negative Pressure Irrigation Methods on Postoperative Pain in Mandibular Molar Teeth with Symptomatic Irreversible Pulpitis: A Randomized Clinical Trial. J Endod. 2018;44(8):1210-1215
57. da Silva, L.A., Nelson-Filho, P., da Silva, R.A. et al. (2010)Revascularization and periapical repair after endodontic treatment using apical negative pressure irrigation versus conventional irrigation plus triantibiotic intracanal dressing in dogs' teeth with apical periodontitis. Oral Surgery, Oral Medicine,Oral Pathology, Oral Radiology, and Endodontics, 109 (5), 779–787.
58. Brunson,M.,Heilborn,C.,Johnson,D.J.&Cohenca, N. (2010) Effect of apical preparation size and preparation taper on irrigant volume delivered by using negative pressure irrigation system. Journal of Endodontics, 36 (4), 721–724.