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Clinical And Radiographical Evaluation Of Silver Nanoparticles Formulations On Pulpectomized Primary Molar

Ahmed Reda Mustafa Abu Elrish[*], Ibrahim Farouk Barakat[**], Alaa Nabil Abbas[***]

[*]Associated Lecturer of Pedodontics and Oral Health Department,Faculty of Dental Medicine (Boys, Cairo), Al-Azhar University, Egypt.

[**]Professor of Pedodontics and Oral Health Department, Faculty of Dentistry (Cairo, Boyes), Al-Azhar University, Egypt.

[***]Lecturer of Pedodontics and Oral Health Department,Faculty of Dentistry (Boys, Cairo), Al-Azhar University, Egypt.

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ABSTRACT

Objectives: This study was directed to evaluate clinical and radiographical effect of silver nanoparticles formulations on pulpectomized primary molar.

Subjects and methods: Seventy two Children between the ages of 4 and 8 who had multiple- rooted primary posterior teeth that needed pulpectomy therapy were chosen. The Nano-Gate helped with the root canal irrigant solutions and oturating materials.

Results: The findings of this RCT revealed that AgNPs have higher Clinical And Radiographic results than NaOCl, this could be attributed to the fact that AgNPs inhibits the development of biofilms and decreases bacterial adhesion. The clinical and radiographic follow-up results of this RCT revealed that the use of AgNPs gel as intracanal medication had better success rates than the use of Ca(OH)2 medication. Furthermore, the results of this RCT revealed that the use of AgNPs formulations had better success rates with passive ultrasonic irrigation (PUI) system and negative pressure irrigation system (EndoVac) than conventional syring system.

Conclusion: Based on the results of this study, PUI and the EndoVac negative pressure system are superior to conventional endodontic needles in terms of their ability to eradicate the E. Faecalis, AgNPs solution was able to reduce colonies of E. faecalis, indicating its potential use as a root canal irrigation, AgNPs gel had higher clinical success rate than Ca(OH)2, indicating its potential use as a interappointment medicament.

Keywords: *Pulpectomy, Primary Posterior teeth, Irrigation, Obturation.*

1. INTRODUCTION

It is generally known that bacteria are the primary etiological agents behind pulpal and periapical disease as well as dentinal caries. The irrigating fluid must have antibacterial properties as well, maybe including the ability to destroy germs in the root canal system and to disinfect canal sections that are inaccessible to mechanical instruments. [(1)] A wide range of bacteria are linked to infections in the primary root canal. According to Cogulu et al. (2004) [(2)] research, Treponema denticola, Porphyromonas gingivalis, and E. faecalis are the three most common bacterial species detected in deciduous root canals. [(1)]Cleaning in root canal therapy refers to the removal of all root canal system contents before and during shaping. Pulp tissue is dissolved and bacteria, smear layer, and dentin debris are removed using endodontic irrigating solutions. [(3)] However, due to morphologic anomalies such as lateral canals, ramifications, and apical deltas, full debridement of the root canal system has turned into a significant therapeutic difficulty. [(4)]There are many irrigation options that have been suggested for use in clinical endodontics. Because it has a wide variety of antibacterial activity and may eliminate different germs, sodium hypochlorite (NaOCl) is the most popular and has helped with canal preparation for many years. However, it also has drawbacks such as toxicity and the potential to cause tissue damage, unpleasant flavor, the failure to completely eradicate all of the microorganisms present in infectious canals, and the potential to physically alter the structure of dentinal canal walls. [(1)] Moreover, the success of endodontic therapy may be adversely affected by the persistent infection. Therefore, it is crucial to treat intra-radicular infection with intra-canal medications such as calcium hydroxide which has enough antibacterial capabilities because of its highly alkaline pH (about 12), which helps clean the root canal area and promote hard tissue regeneration. However, with the use of calcium hydroxide, there is a chance that may have a negative impact on the radicular dentin's mechanical, chemical, and physical characteristics. [5]The optimum intra-canal medication is still being developed in an effort to strike a balance between preserving a hospitable niche for stem cells to rebuild the lost or damaged tooth structures and delivering appropriate and persistent antibacterial effects. Alternative antimicrobials have recently been proposed, including Silver Nanoparticles, Calcium Hypochlorite, Chitosan-based Medicines, Bioactive Glass, and others. [5]The information that is now available indicates that there are various NP types that are employed in endodontics. Nanoparticles of silver and gold are among them. Silver nanoparticles (AgNPs) are more effective when they are reduced to the nanoscale, which also improves their biocompatibility and antibacterial properties. [1] As an intra-canal medication, 0.02% AgNPs gel was also tested and they discovered that it had a 99.4% as antibacterial effect after 24 hours and a 99.9% as antibacterial effect after 7 days for 3 weeks E. faecalis biofilm. Once inside the bacterial cells, the Ag^+ released from AgNPs often produces reactive oxygen species (ROS) that cause oxidative stress. [6]

In actuality, it is generally acknowledged that cleaning and shaping treatments do not entirely eradicate all germs present in the root canal despite the high success rates of endodontic therapy. [7] The conventional endodontic irrigation syringe and needle is the most commonly used because it is very easy to manipulate and offers good control over the volume of irrigant delivered and needle depth at any given time. However, the positive pressure utilized to inject the irrigant into the canal has raised concerns about its safety, though, as it could cause significant tissue damage and postoperative pain if the solution were to extrude to the periapex. [3]Currently, various irrigation techniques and devices are being used to improve the disinfection of root canal systems. In order to improve the efficiency of canal disinfection, passive ultrasonic irrigation (PUI) was developed to stir the irrigant solution that had previously been injected into the canal. Although PUI doesn't totally eradicate bacteria from the root canals, studies have shown that it is much more successful than traditional endodontic needle irrigation at reducing the number of germs present there. [3]A negative pressure irrigation system called EndoVac was created to securely administer irrigant solutions into the apical part of the canal. A vacuum line is connected to a master delivery/suction tip, a macro-cannula, and a micro-cannula in this apparatus. With the help of the macro-cannula and micro-cannula, the irrigant is delivered into the pulp chamber while utilizing this technique and is then forced into the root canals by negative pressure. [3]

Therefore, the purpose of this study was Clinical And Radiographical evaluate the effect of formulations containing silver nanoparticles on pulpectomized primary molars.

2. SUBJECTS AND METHODS

Materials And Devices:

A list of the items utilized in this investigation is presented together with relevant information (manufacturers and descriptions) is designated in Table (1).

Table (1): The type, manufacture, and supplier of the restorative materials employed in this study:

	Material	Type	Composition	Manufacturer
1.	Silver- nanoparticles solution (Fig. 1)	Irrigation solution (AgNPs 0.02%)	Powder: Silver-nanoparticles (size 17 nm). Liquid: Deionized water.	Nano-gate Company, Egypt.
2.	Sodium hypochlorite solution (Fig. 2)	Irrigation solution (2.5%)	Sodium hypochlorite.	Arab Industries, Clorox, Egypt

3.	Silver- nanoparticles gel (Fig. 3)	Intracanal dressing material	Powder: Silver-nanoparticles (size 17 nm). Liquid: Methylcellulose.	Nano-gate Company, Egypt.
4.	Metapex plus paste (Fig. 4)	Intracanal dressing material	10% Calcium hydroxide with Iodoform paste	META BIOMED, USA
5.	GIC (Fuji IX) (Fig. 4)	Base-material	Powder: Aluminosilicate glass. Liquid: 20%-22% polyacrylic acid.	GC Corporation, Tokyo, Japan
6.	Paper points	Sampling collecting material	Sterile paper points size #15.	Meta Biomed
7.	Composite resin	Restoration for the access cavity	Hybrid resin composite.	Ceram.x; Dentsply Sirona.
8.	Stainless-steel (SSC)	Final restoration	Prefabricated metallic crowns.	3M ESPE, USA

Table (2): The list of devices employed in this investigation, as well as its manufacturer:

	Device	Manufacturer
1.	Monoject syringe with a 27- gauge side-vented needle.	Vista Dental Product, Racine WI, USA.
2.	PUI with an IrriSafe tip	NSK; Nakanishi Inc, Japan.
3.	EndoVac	Discus Dental, Culver City, CA.
4.	Paste mixer	PDM-300; Daewha Tech.
5.	Transmission electron microscope	JEM-2100 TEM; JEOL.

6.	Spectrophotometer	via DU-650 UV-Vis Spectrophotometer; Beckman

Ethical Consideration:

The ethics committee of the Faculty of Dental Medicine at Al-Azhar University in Cairo, boys, gave its approval before this study could be conducted. (EC. Ref. No.945/1943)

Before the research began, each parent received a thorough explanation of the process and was asked to sign a permission form.

Study Setting and Population:

From patients utilizing the outpatient clinic of the Pedodontics Department at the Faculty of Dental Medicine (Boys, Cairo), Al-Azhar University, 72 healthy children between the ages of 4 and 8 were chosen.

Eligibility criteria for the selected teeth:

Inclusion criteria: [(29-30)]

Children aged between 4-8 years,Parents' and patients' acceptance and cooperation ,Primary posterior teeth with deep carious lesion with uncontrolled bleeding after pulp amputation.

Apical root resorption is less than 1/3 of roots, With History of spontaneous, unprovoked toothache and Sufficient coronal tooth structure to support a rubber dam and to be restored with stainless steel crown (SSC).

Exclusion criteria: [(29-31)]

Children with parents refused to participate in the study or Uncooperative child, Childs with systemic diseases that can affect their immunity or cooperation,Children have mobile tooth that was indicted for extraction, Or with resorption of more than 2/3 of Root, Root canal obliteration or anatomic anomalies, Children who had taken antibiotics up to two weeks prior to the sampling, as well as those who had any systemic impairment, non-restorable teeth, perforated pulpal floors, and excessive mobility or pathological root resorption, would be disqualified.

PICO:

- **(P) Population:** Children aged between 4 and 8 years with primary molars with deep carious lesions require pulpectomy treatment.
- **(I) Intervention:** Pulpectomy treatment after irrigation with 0.02% AgNPs solution and use of AgNPs gel for intracanal dressing.
- **(C) Control:** Pulpectomy treatment after irrigation with 2.5% NaOCl solution and use of $Ca(OH)_2$ for intracanal dressing.
- **(O) Outcomes:**

(A) Primary outcomes:

- Assessing the clinical and radiological outcomes of pulpectomies primary molars following irrigation with 0.02% AgNPs solution and intracanal dressing application with AgNPs gel.
- Assessing the clinical and radiological outcomes of pulpectomies primary molars following irrigation with a 2.5% NaOCl solution and intracanal dressing application with $Ca(OH)_2$.

(B) Secondary outcomes:

- Evaluation of the antimicrobial activity, 0.02% AgNPs irrigation solution and comparing its antimicrobial activity with 2.5% NaOCl solution.
- An assessment of the impact of irrigation delivery methods on the elimination of microorganisms during primary molar pulpectomy therapy.

Sample Size Calculation:

The estimated sample size,was 72 participants divided randomly into 2 equal groups (n=36) according to the type of the used irrigation solutions and intracanal dressing materials Then each mean group was further subdivided into 3 subgroups (n=12) according to the type irrigation system used . Statistical Power Analyses Version 3.1.9.2 of G Power was used to calculate the sample size. A two-sided hypothesis test was used to generate the sample size with an effect size of (0.92), a power of (0.8), and a significance level (error) of 0.05 for the data.

Patient Consent:

Consent was obtained from the children's parents.

Preoperative Assessment:

A. History of the Patient:

Complete medical and drug history as well as patient's data (name, gender and age) were collected. As regarding the medical history, all patients were free from any systemic diseases.

B. Clinical Examination:

- Extraoral examination:

Include examination of face and general appearance **.**

- Intraoral examination
  - Soft tissue includes examination of Gingiva, tongue and floor of mouth
  - Hard tissue examination includes Teeth

Grouping:

A total of 72 primary molars needed pulpectomy treatment were involved in this RCT and divided randomly into 2 equal groups (n=36) according to the type of the used irrigation solutions and intracanal dressing materials as follows:

- Group 1: Primary molars irrigated with AgNPs solution and obturated with a mix of Nanosilver gel and Ca(HO)2.
- Group 2: Primary molars irrigated with NaOCl solution and obturated with Ca(HO)2. Then each mean group was further subdivided into 3 subgroups (n=12) according to the type irrigation system used as the following:

1. Sub-group A: Passive ultrasonic irrigation (PUI) system.
2. Sub-group B: Negative pressure irrigation system (EndoVac).
3. Sub-group C: Conventional endodontic irrigation syringe and needle.

Preparation of AgNPs solution: [(24)]

The following is how the silver nanoparticle solution was created.

- A reaction vessel was filled with 100 mL of a 0.02 M $AgNO_3$ solution, followed by the addition of a second solution containing 0.1 g of gallic acid and 10 mL of deionized water while being stirred magnetically.
- Using a 1.0 M NaOH solution, the reaction mixture's pH was quickly brought to 11.
- After the pH was adjusted, the mixture was stirred for an additional twenty minutes.

Preparation of AgNPs gel: [(25)]

- Every chemical employed in the research was analytical grade, meaning that its purity was 95%.
- AgNPs powder, measuring 17 nm in size, was combined with methylcellulose to create AgNPs in gel form.
- Using a paste mixer, one gram of methylcellulose was added to ten milliliters of distilled water.
- With constant stirring, the solution combination was heated to 70°C.
- It was decided to let the gel solution cool to room temperature.
- Subsequently, the gel solution received one gram of 50 ppm AgNPs (0.02 µg/ml concentration) and was agitated for one hour.

- **Intervention:**

1. pulpectomy procedure:

After injection of local anesthetic solution, the involved tooth was isolated with a rubber dam before the beginning of any operative procedure. [(192, 194)]The caries removal and access cavity opening were performed in necrotic primary posterior teeth with a sterile round carbide bur. [(30, 31)]The mechanical cleaning and shaping of canals with endodontic files were then performed. [31, 32]Irrigation was performed according to special protocols in the subject grouping. After irrigation, and microbial sample collection, the placement of the obturating material was performed according to special protocols in the subject grouping. **[30-32]**A suitable base material of glass ionomer cement (GIC) was used over the intracanal dressing material. [31-32] After that, the final restoration of composite was placed in each cavity and the tooth was finally restored with SSC. [32]All treatments procedures were performed in a single visit. [31]

2. **Irrigation Protocol:**

After mechanical root preparation, the root canals of each involved tooth were cleaned with one of the tested irrigant solutions (0.02% AgNPs or 2.5% NaOCl) according to the allocated group in the subject grouping.Between each filing 2 mL of 0.02%AgNPs or 2.5% NaOCl was used after instrumentation. [1, 29]In accordance with the sub-groups to which they have been assigned, the irrigation solutions were applied and stirred with one of the endodontic irrigation systems. [3] For the PUI sub-group the irrigation solution was ultrasonically stirred for 30 seconds using an IrriSafe tip #20/25 inserted into the canal at working length and moved up and down. [3]For the EndoVac sub-group, the macrocannula positioned in the cervical and medium thirds of the root canal was used to suction 2 mL of each irrigation solution into the pulp chamber using the master delivery tip.

[3] For the Monoject sub-group, two milliliters of each irrigation solution were injected into the canal using a Monoject syringe fitted with a 27-gauge side-vented needle that was positioned two millimeters below working length. [3] For all sub-groups; the irrigation was accomplished with a final rinse of 1 mL of each tested solution for 2 min followed by 2 mL of saline for 1 minute. [1, 29]

Observation:

Clinical and radiographic evaluation: [33-34]

Clinical2. and radiographic evaluations were performed at 4 different intervals (after 1-month, 3-months, 6-months, 9-months)

Clinical criteria of success:

Absence of pain, swelling, fistula, sensitivity to percussion and Absence of pathological mobility of the tooth.

Radiographic criteria of success:

Absence of periapical and furcation radiolucency,No widening of periodontal ligament space, Neither external nor internal root resorption is more than 1/3 of its length and Absence of canal calcification. **Statistical analysis of the data:**

The collected data were tabulated and statistically analyzed using SPSS version 20. The reduction in the data obtained by counting CFU after the treatment will be transformed into logarithmic (log10) values. The normality of data distribution was assessed by Shapiro-Wilk Test.Student t-test was used to analyze values between two groups. One-way analysis of variance was used to analyze values between more than two groups, and the Tukey honestly significant difference (HSD) (post hoc) test was used to analyze values for multiple intergroup comparisons.The significance level will be set at P

≤ 0.05.

3. RESULTS

1. **Clinical results:**

1.1. Comparison of clinical success rate results at 1 month:

The results of clinical success rates after 1 month were represented at Table (3) and Figure (1).

Regarding the type of the irrigation solution, the results of the chi-square test showed that, using both PUI and EndoVac irrigation systems, AgNPs irrigation solution had the higher clinical success rates (100%) than NaOCl irrigation solution (91.67%). However, the results revealed that the use of conventional syringe resulted in insignificantly higher success rate with AgNPs irrigation solution (91.67%) when compared with NaOCl irrigation solution (83.33%).

Furthermore, regarding the irrigation system the chi-square test showed that the use of PUI and EndoVac irrigation systems with AgNPs irrigation solution had the higher clinical success rates (100%) than the use of conventional syringe (91.67%). However, the use of PUI and EndoVac irrigation systems with NaOCl irrigation solution had greater clinical success rates (91.67%) than the use of traditional syringes (83.33%) when it came to irrigation systems, according to the chi-square test.

Table (3): Comparison of clinical success rates results at 1 month:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	12 (100%)	11 (91.67%)	8.69	NaN
EndoVac	No. (%)	12 (100%)	11 (91.67%)	8.69	NaN
Conventional syringe	No. (%)	11 (91.67%)	10 (83.33%)	3.17	0.074 ns
P-value		Nan	0.095 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05. NaN; Not a number (not combuted)

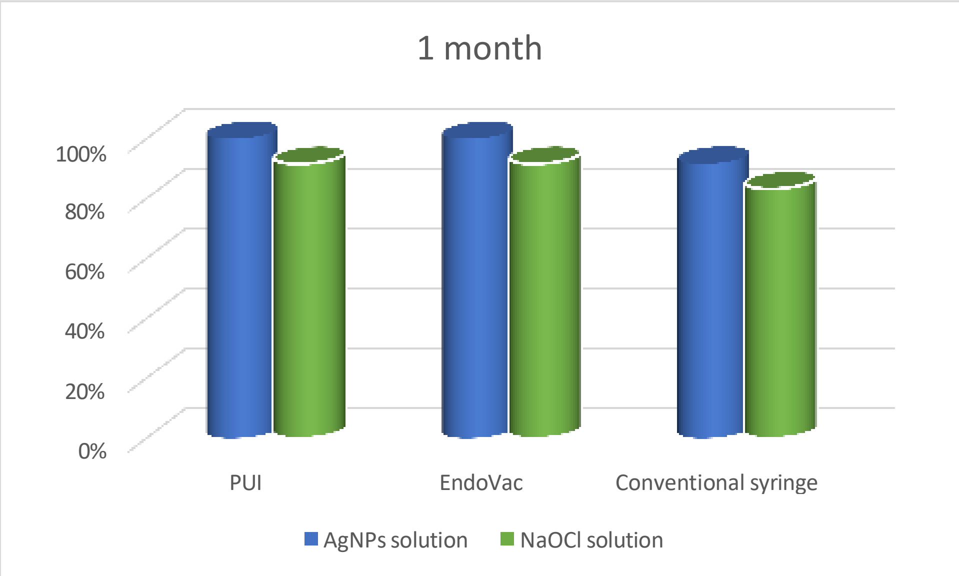

Fig. (1): Illustrated diagram showing clinical success rate results after 1 month.

1.2. Comparison of clinical success rate results at 3 months:

The results of clinical success rates after 3 months were represented at Table (4) and Figure (2).

In terms of irrigation solution type, the chi-square test findings indicated that AgNPs irrigation solution had marginally greater clinical success rates (91.67%) than NaOCl irrigation solution (83.33%) when employing both PUI and EndoVac irrigation systems. Furthermore, the findings showed that, in comparison to the 75% success rate with NaOCl irrigation solution, the use of a typical syringe with AgNPs irrigation solution produced an insignificantly greater success rate (83.33%).

Furthermore, using PUI and EndoVac irrigation systems with AgNPs irrigation solution had considerably greater clinical success rates (91.67%) than using a normal syringe (83.33%) when it came to irrigation systems, according to the results of the chi-square test. However, the chi-square test revealed that when it came to irrigation systems, the use of PUI and EndoVac irrigation systems with NaOCl irrigation fluid had higher clinical success rates (83.33%) than the use of conventional syringes (75%).

Table (4): Comparison of clinical success rates results at 3 months:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	11 (91.67%)	10 (83.33%)	3.17	0.074 ns
EndoVac	No. (%)	11 (91.67%)	10 (83.33%)	3.17	0.074 ns

Conventional syringe	No. (%)	10 (83.33%)	9 (75%)	2.1	0.147 ns
P-value		0.095 ns	0.228 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

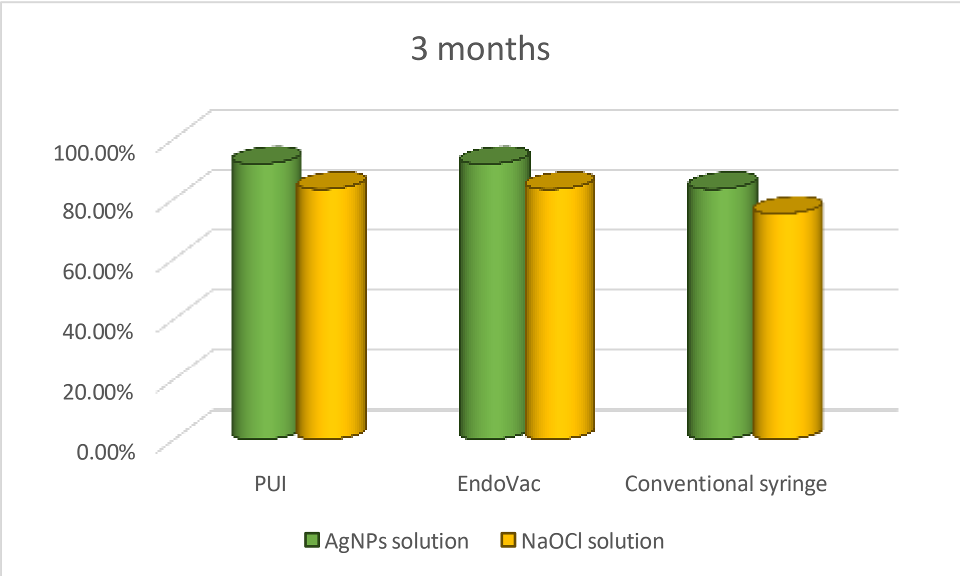

Fig. (2): Illustrated diagram showing clinical success rate results after 3 months.

1.3. Comparison of clinical success rate results at 6 months:

The results of clinical success rates after 6 months were represented at Table (5) and Figure(3).Regarding irrigation solution type, the results of the chi-square test showed that when using both PUI and EndoVac irrigation systems, AgNPs irrigation solution had significantly higher clinical success rates (91.67%) than NaOCl irrigation solution (75%). Additionally, the results demonstrated that using a standard syringe with AgNPs irrigation solution resulted in a significantly higher success rate (83.33%) compared to the 66.67% success rate with NaOCl irrigation solution.

Additionally, the chi-square test findings showed that when it comes to irrigation systems, employing PUI and EndoVac irrigation systems with AgNPs irrigation solution had much higher clinical success rates (91.67%) than using a standard syringe (83.33%). The use of PUI and EndoVac irrigation systems with NaOCl irrigation fluid, on the other hand, had greater clinical success rates (75%) than the use of traditional syringes (66.67%), according to the results of the chi-square test.

Table (5): Comparison of clinical success rates results at 6 months:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	11 (91.67%)	9 (75%)	10.0	0.001*
EndoVac	No. (%)	11 (91.67%)	9 (75%)	10.0	0.001*
Conventional syringe	No. (%)	10 (83.33%)	8 (66.67%)	2.1	0.006*
P-value		0.095 ns	0.315 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

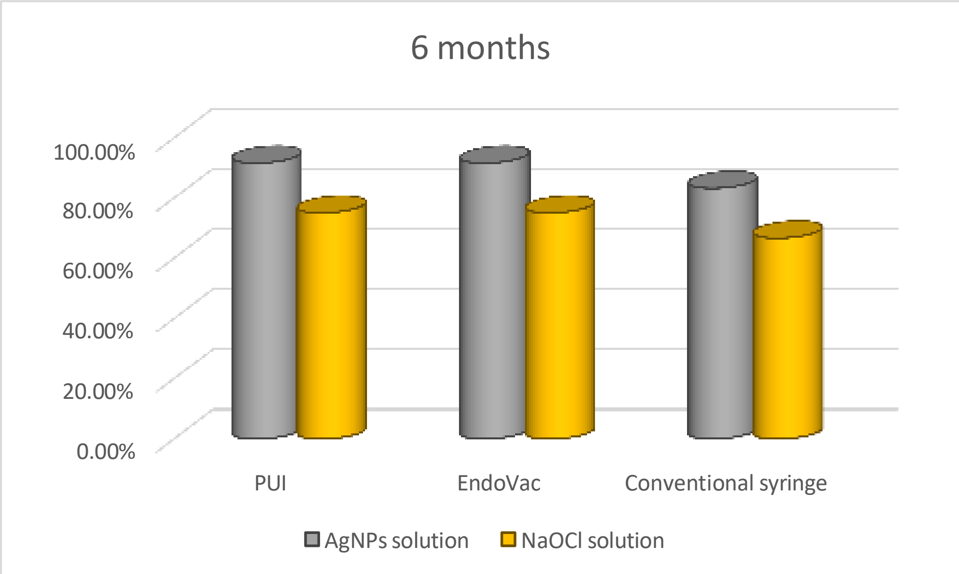

Fig. (3): Illustrated diagram showing clinical success rate results after 6 months.

1.4. Comparison of clinical success rate results at 9 months:

The results of clinical success rates after 9 months were represented at Table (6) and Figure (4).AgNPs irrigation solution exhibited marginally greater clinical success rates (83.33%) than NaOCl irrigation solution (75%), according to the findings of the chi-square test, when both PUI and EndoVac irrigation systems were used. Furthermore, the outcomes showed that the success rate of 75% with AgNPs irrigation solution using a normal syringe was marginally greater than the 66.67% success rate with NaOCl irrigation solution.Furthermore, utilizing PUI and EndoVac irrigation systems with AgNPs irrigation solution had significantly greater clinical success rates (83.33%%) than using a normal syringe (75%), according to the results of the chi-square test. The chi-square test findings showed that the use of PUI and EndoVac irrigation systems with NaOCl irrigation fluid had higher clinical success rates (75%) than the use of conventional syringes (66.67%).

Table (6): Comparison of clinical success rates results at 9 months:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	10 (83.33%)	9 (75%)	2.10	0.147 ns
EndoVac	No. (%)	10 (83.33%)	9 (75%)	2.10	0.147 ns
Conventional syringe	No. (%)	9 (75%)	8 (66.67%)	1.67	0.195 ns
P-value		0.228 ns	0.315 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

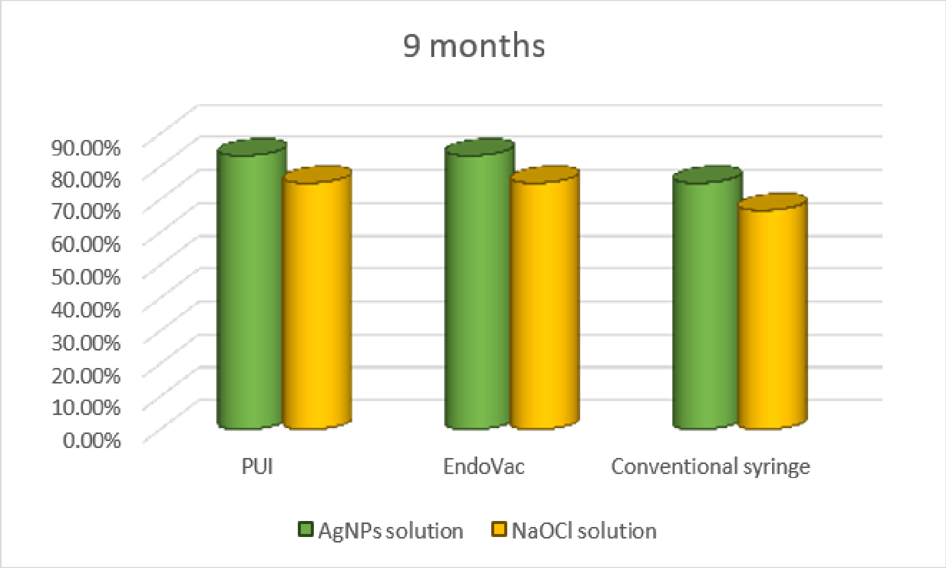

Fig. (4): Illustrated diagram showing clinical success rate results after 9 months.

2. Radiographic results:

2.1. Comparison of radiographic success rate results at 1 month:

The results of radiographic success rates after 1 month were represented at Table (7) and Figure (5).

In terms of irrigation solution type, the chi-square test findings indicated that AgNPs irrigation solution had insignificantly greater radiographic success rates of 91.67% than NaOCl irrigation solution of 83.33% when employing EndoVac irrigation system. But when compared to NaOCl irrigation solution, the results showed that using a conventional syringe and PUI produced the same radiographic success rate with AgNPs irrigation solution (83.33% and 91.67%) respectively.

Additionally, the chi-square test revealed that the radiographic success rates of using PUI and EndoVac irrigation systems with AgNPs irrigation solution were insignificantly higher (91.67%) than those of using a normal syringe (83.33%) in terms of irrigation system utilization. However, the chi- square test revealed that when it comes to irrigation systems, the use of PUI irrigation system with NaOCl irrigation solution had higher radiographic success rates (91.67%) than the use of conventional syringes and EndoVac (83.33%).

Table (7): Comparison of radiographic success rates results at 1 month:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	11 (91.67%)	11 (91.67%)	0	1 ns
EndoVac	No. (%)	11 (91.67%)	10 (83.33%)	3.17	0.074 ns
Conventional syringe	No. (%)	10 (83.33%)	10 (83.33%)	0	1 ns
P-value		0.095 ns	0.143 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

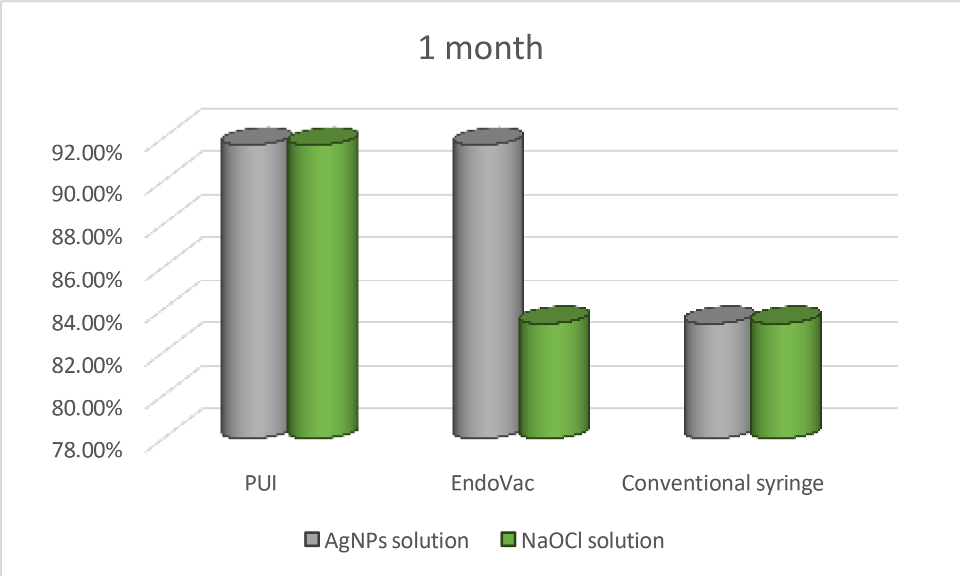

Fig. (5): Illustrated diagram showing radiographic success rate results after 1 month.

2.2. Comparison of radiographic success rate results at 3 months:

The results of radiographic success rates after 3 months were represented at Table (8) and Figure (6).

Regarding irrigation solution type, the results of the chi-square test showed that while using a PUI irrigation system, AgNPs irrigation solution had radiographic success rates of 91.67%, which was higher than NaOCl irrigation solution's 83.33%. However, the results demonstrated that utilizing a EndoVac and a conventional syringe provided the same radiographic success rate with AgNPs irrigation solution (83.33% and 75%, respectively) as compared to NaOCl irrigation solution.

Furthermore, the chi-square test showed that, in terms of irrigation system use, the radiographic success rates of employing PUI irrigation systems with AgNPs irrigation solution were significantly higher (91.67%) than those of using an EndoVac (83.33%) and a normal syringe (75%). The use of PUI and EndoVac irrigation systems with NaOCl irrigation solution, on the other hand, had greater radiographic success rates (83.33%) than the use of conventional syringes (75%), according to the results of the chi-square test.

Table (8): Comparison of radiographic success rates results at 3 months:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	11 (91.67%)	10 (83.33%)	3.17	0.074 ns
EndoVac	No. (%)	10 (83.33%)	10 (83.33%)	0	1 ns
Conventional syringe	No. (%)	9 (75%)	9 (75%)	0	1 ns
P-value		0.006*	0.228 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

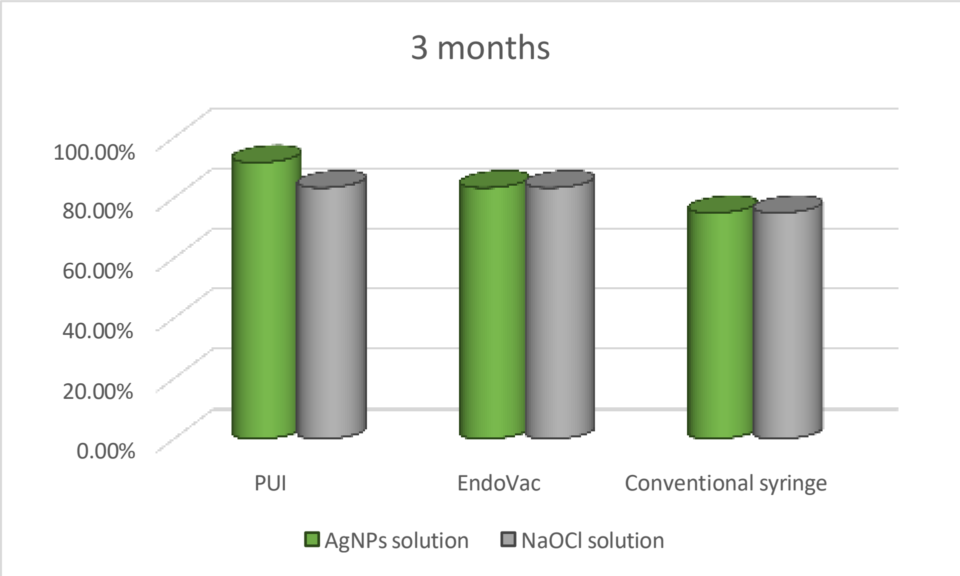

Fig. (6): Illustrated diagram showing radiographic success rate results after 3 months.

2.3. Comparison of radiographic success rate results at 6 months:

The results of radiographic success rates after 6 months were represented at Table (9) and Figure (7).

Regarding irrigation solution type, the results of the chi-square test showed that while using a PUI and EndoVac irrigation systems, AgNPs irrigation solution had radiographic success rates of 83.33%, which was marginally higher than NaOCl irrigation solution's 75%. However, the results demonstrated that utilizing a conventional syringe provided the insignificantly higher radiographic success rate with AgNPs irrigation solution (75%) as compared to NaOCl irrigation solution (66.67%).

Furthermore, the chi-square test showed that, in terms of irrigation system use, the radiographic success rates of employing PUI and EndoVac irrigation systems with AgNPs irrigation solution were substantially higher (83.337%) than those of conventional syringe (75%). Also, the use of PUI and EndoVac irrigation systems with NaOCl irrigation solution had greater radiographic success rates (75%) than the use of conventional syringes (66.67%), according to the results of the chi-square test.

Table (9): Comparison of radiographic success rates results at 6 months:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	10 (83.33%)	9 (75%)	2.1	0.147 ns
EndoVac	No. (%)	10 (83.33%)	9 (75%)	2.1	0.147 ns
Conventional syringe	No. (%)	9 (75%)	8 (66.67%)	1.67	0.195 ns
P-value		0.228 ns	0.315 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

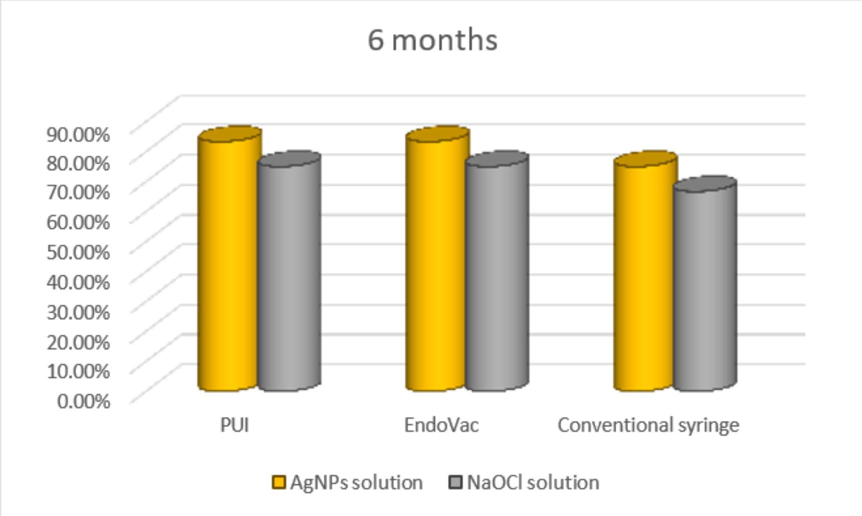

Fig. (7): Illustrated diagram showing radiographic success rate results after 6 months.

2.4. Comparison of radiographic success rate results at 9 months:

The results of radiographic success rates after 9 months were represented at Table (10) and Figure (8).

Regarding irrigation solution type, the results of the chi-square test showed that while using a PUI irrigation system, AgNPs irrigation solution had radiographic success rates of 83.33%, which was marginally higher than NaOCl irrigation solution's 75%. However, the results demonstrated that utilizing a PUI provided the higher radiographic success rate with AgNPs irrigation solution (75%) as compared to NaOCl irrigation solution (66.67%). Furthermore, the conventional syringe provided the higher radiographic success rate with AgNPs irrigation solution (66.6775%) as compared to NaOCl irrigation solution (58.33%).

Furthermore, the chi-square test showed that, in terms of irrigation system use, the radiographic success rates of employing PUI irrigation systems with AgNPs irrigation solution were higher (83.33%) followed by those of using an EndoVac (75%) and then the conventional syringe (66.67%). The use of PUI irrigation system with NaOCl irrigation solution, on the other hand, had greater radiographic success rates (75%) followed by the use of EndoVac system (66.67%) and then the use of conventional syringes (58.33%), according to the results of the chi-square test.

Table (10): Comparison of radiographic success rates results at 9 months:

Variable	Success rate	AgNPs solution	NaOCl solution	Chi-Square	P-value
PUI	No. (%)	10 (83.33%)	9 (75%)	2.1	0.147 ns
EndoVac	No. (%)	9 (75%)	8 (66.67%)	1.67	0.195 ns
Conventional syringe	No. (%)	8 (66.67%)	7 (58.33%)	1.48	0.223 ns
P-value		0.228 ns	0.315 ns		

*; Significant at P<0.05. ns; Non-significant at P>0.05.

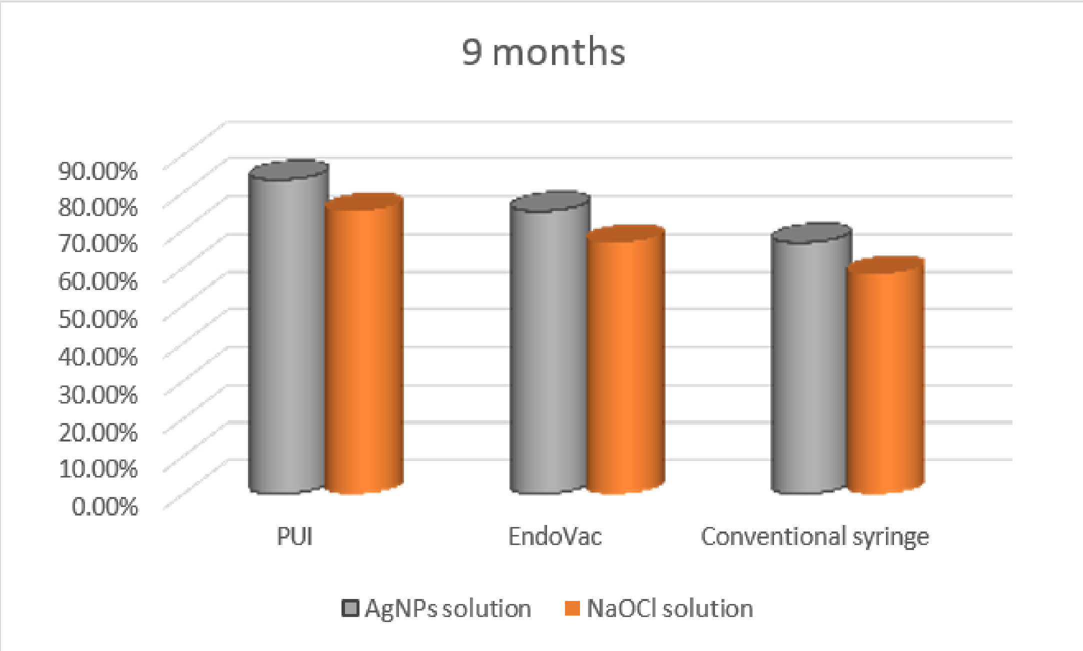

Fig. (8): Illustrated diagram showing radiographic success rate results after 9 months.

4. DISCUSSION

The objectives of root canal irrigation are to mechanically and chemically separate pulp tissue, dentine debris, and the smear layer (instrumentation products), as well as to remove planktonic and biofilm microorganisms and their byproducts from the root canal wall and the root canal system. [35] In this RCT NaOCl was selected as a control irrigation solution because it is considered the gold standard for chemically disinfecting root canals and it is the most significant substance utilized as an irrigant in root canal therapy due to its bactericidal and anti-biofilm effect and its capacity to inactivate endotoxins. [22, 35, 36]

On the other hand, it was found that dentin and the biomass in the root canal may inactivate its antibacterial activity, despite the fact that it has many benefits like a broad bactericide spectrum and the ability to remove organic debris; additionally, irrigation with NaOCl weakens the bond between dentin and resin. [23] Also, Suzuki et al. (2019) [37] reported that NaOCl damages the periapical tissues toxically and lowers the dentine's elastic modulus and flexural strength.

In this RCT AgNPs solution was used as an tested irrigation solution because the benefit that AgNPs have over NaOCl is that they have the same bactericidal action but also have the ability to remove smear layers, something that NaOCl cannot do according to González-Luna et al. (2016)

[24]. Also, Besinis et al. (2017) [38] reported that because AgNPs irrigation solution has a stronger antibacterial effect, it may be used to irrigate root canals. Furthermore, according to Afkhami et al. (2017) [27] AgNPs outperformed 2.5% NaOCl antibacterial and cytotoxic effects. According to a study by Suzuki et al. (2019) [37], the mechanical characteristics of dentine were not considerably impacted by root canal irrigation with a AgNPs solution.Furthermore, it was discovered that the usage of AgNPs at low concentrations had the same bactericidal effect as 5.25% NaOCl and had a reduced cytotoxic impact, thus 0.02% of AgNPs was chosen as the concentration for both the irrigation solution and the intracanal medicine gel in this RCT. [28, 39]

The goal of the various techniques to improve irrigation is to ensure the proper distribution of the irrigants throughout the root canal system, enabling more regular cleaning of the difficult-to-reach areas. [14, 15] Thus, one of the objectives of this RCT was to evaluate how well various irrigation methods could clean root canals in a safe and effective manner.

A number of delivery techniques are used for root canal irrigation, from the traditional syringe- needle administration technique to machine-driven systems that incorporate motorized pumps, vibrating tips, and sonic or ultrasonic energy. [8, 9] The conventional approach of irrigating the root canal in this RCT was done using a syringe and small size 27-gauge needle to enter the apical canal since, when used carefully, needles can be sufficient and effective. [16]

Since negative pressure irrigation is a safe method of irrigating most apical canals, it was used in this RCT. [11] Furthermore, research has shown that the negative pressure method can improve the apical root canal's cleaning quality without running the danger of the solution extruding. [12, 13]

In this RCT PUI system was utilized because it was found that by using ultrasonic tips to transmit the solutions directly into the canal space, ultrasonic irrigation may effectively clean even the most difficult areas, including the long, narrow isthmuses between two canals. [14, 15]

In this RCT AgNPs gel and $Ca(OH)_2$ ready-made past were used as intracanal medications because it is advised to use an antibiotic intracanal medication in order to test the clinical and radiographic outcomes of combination of antimicrobial irrigation solution

Furthermore, $Ca(OH)_2$ was administered intracanally in this RCT as it is the most popular intracanal disinfectant due to its extensive antibacterial spectrum, alkalizing effect, and capacity to reduce inflammation. [40] Nevertheless, $Ca(OH)_2$ is less successful in disinfecting canals if an established E. faecalis biofilm is present, since this organism is often found in root canal infections that persist. [26] Thin mixes of $Ca(OH)_2$ may not be the best choice for intracanal dressings since the antibacterial activity of $Ca(OH)_2$ is dependent on hydroxyl ion release in an aqueous surroundings.

[41] However, the current investigation employed a 10% concentration of $Ca(OH)_2$, which is comparable to previously recommended values. [41, 42]

In this RCT AgNPs in gel form was used as intracanal medicament due to the highly developed microbial resistance of a wide range of bacteria.

The findings of this RCT revealed that AgNPs have higher Clinical And Radiographical results because it have higher antimicrobial effect against E. Facealis than NaOCl, this could be attributed to the fact that AgNPs inhibits the development of biofilms and decreases bacterial adhesion. [26] Moreover, AgNPs have been shown to be efficient against mature, established biofilms, yet their effectiveness is dependent on their concentration. [43, 44]

However, NaOCl was employed to facilitate the hydrolysis of organic tissue found in the pulp chamber and root canal systems. It has been shown that this chemical reaction causes tiny carbon dioxide and ammonia bubbles to develop. Because the root canal functions like a closed tube system, these bubbles become trapped in the closed end of the tube. [3] This could explain the limited antimicrobial effect of NaOCl solution in this RCT.

AgNPs gel was found to have superior clinical and radiographic effects as an intracanal dressing in the current RCT. This is because thick mixtures of $Ca(OH)_2$ may not be the best option for intracanal dressings because the antimicrobial efficacy of $Ca(OH)_2$ is linked to hydroxyl ion release in an aqueous environment. [26] Moreover, silver inhibits th development and creation of biofilms in addition to deactivating essential bacterial processes. [26, 45]

The RCT's findings showed that using a conventional needle for irrigation produced lower antibacterial results as well as the lower clinical and radiographic success rates. This could be explained by the fact that the conventional needle's irrigant exchange only extends one to three millimeters past the needle tip, and that the type of needle and irrigant flow affect how effective irrigation is. [10, 17]

Furthermore, it was discovered that side-vented (tip) needles may offer a safer irrigation in positive pressure irrigation than open-ended needles. [10, 17]

When compared to positive pressure irrigation, several studies have demonstrated enhanced cleanliness or an antibacterial impact in the most apical canal when using EndoVac. [19, 20, 21] Nevertheless, the results of this RCT showed that the use of PUI and EndoVac had the same effect on the E. Faecalis bacteria, which contradicted the findings of other studies.

The results of this current RCT showed that compared to the conventional syringe, the negative pressure and positive pressure irrigation devices had a better clinical success rate. The reason for this might be because these irrigation systems were able to distribute the irrigation solution more aptly and safely without worrying about extrusion. These results are consistent with those of other studies that have indicated that the apical root canal's cleaning quality may be improved by the negative and positive pressure approach without running the risk of the solution extruding. [12, 13]

These findings further support previous research showing that the EndoVac system is substantially more efficient than a traditional irrigation needle at clearing debris from root canals at 1 mm below working length, but not appreciably better at 3 mm below working length. [46] Moreover, it has been shown that using EndoVac instead of a conventional needle result in superior apical third debridement. [47]

Additionally, the use of ultrasonic tips to transfer solutions directly into the canal space in this RCT contributed to the PUI system's higher clinical and radiographic success rates. Ultrasonic irrigation can successfully clean even the most challenging areas, such as the long, narrow isthmus between two canals. [14, 15] Furthermore, it was discovered that PUI eliminates more pulpal tissue and dentine debris in the canal than syringe needle irrigation because of its increased irrigating flow and velocity. [9, 18]

5. CONCLUSIONS

Based on the current study's findings, it can be said that:

1. In terms of clinical and radiographic success, PUI and the EndoVac negative pressure device outperform

traditional endodontic needles.

2. AgNPs solution had higher clinical success rate than NaOCl, indicating its potential use as a root canal irrigation.
3. AgNPs gel had higher clinical success rate than $Ca(OH)_2$, indicating its potential use as a interappointment medicament.

AgNPs solutions had higher clinical success rate than **NaOCl**, indicating its potential use as a irrigation solution.

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