



**ENHANCED VISUALIZATION OF THE ROOT CANAL MORPHOLOGY USING A
ENDO-RADIOPAQUE SOLUTION- AN IN-VITRO STUDY**

**Dr. Palagiri Sai Radhika Priyanjali^{1*}, Dr. Pradeep P. R.², Dr. Ananthakrishna S.³, Dr. Yuva Rani P.⁴ and
Dr. Akshata M. H.⁵**

^{1,4,5}Post Graduate Student Department of Conservative Dentistry and Endodontics M.R Ambedkar Dental College and Hospital Bangalore.

²Principal and Professor Department of Conservative Dentistry and Endodontics M.R. Ambedkar Dental College and Hospital Bangalore.

³Professor and HOD Department of Conservative Dentistry and Endodontics M.R. Ambedkar Dental College and Hospital Bangalore.



***Corresponding Author: Dr. Palagiri Sai Radhika Priyanjali**

Post Graduate Student Department of Conservative Dentistry and Endodontics M.R Ambedkar Dental College and Hospital Bangalore.

Article Received on 10/09/2024

Article Revised on 30/09/2024

Article Accepted on 20/10/2024

ABSTRACT

Introduction:- Accurate knowledge of the root canal anatomy, comprehensive assessment of radiographic images, proper access to the canal orifices, thorough chemo-mechanical instrumentation and 3D obturation is essential for successful root canal therapy. The genetic and ethnic variations in the root canal anatomy are fairly common. Thus the internal root canal anatomy must be determined as it is used as a basis for the course of endodontic therapy. Water-soluble contrast agents have been used with varying degrees of success. Contrast media can be categorized into ionic and non-ionic types. The non-ionic type has lower osmolality and reduced chemo toxic effects and is better tolerated and less viscous than the ionic type. The contrast media we are using here for the experiment are Iopamidol and iohexol. For this experiment, we have chosen single rooted tooth with mature apices.

Objectives:- The main aim of this present study is to investigate the efficacy of two different non-ionic based contrast media for visualization of the root canal morphology.

Methodology:- In vitro experiment

Sample collection and preparation:- For this study we have collected 30 extracted human single rooted teeth and are further divided into 2 groups of 15 teeth each and the groups are named as groups A, B based on the use of different contrast media Iopamidol and iohexol respectively. Preparation of teeth will be done by access opening on all the teeth and radiographs are taken.

Application and evaluation of contrast media:- After the access opening the contrast media was introduced passively into the pulp chamber using a double-sided vented 30 G endodontic irrigation needle as per the division of the groups of teeth. After one-minute RVGs was taken in order to analyze the depth of the contrast media ingress. Canal patency was determined by using no 6 K file and working length was determined by no 10 K file and canal enlargement was done till no 30 K file and 0.5 mL of contrast media was introduced into each

canal using a positive pressure with a double side-vented 30-gauge endodontic irrigation needle and successive RVG was performed.

Evaluation:- To evaluate the depth of media ingress and to identify the aberrant root canal anatomy, 2 endodontist who were blinded to the study assessed the results using scoring criteria:-

1. Grade 0: No radiopacity
2. Grade 1: Radiopacity up to middle third.
3. Grade 2: Radiopacity up to apical third.
4. Grade 4: Radiopacity of the apical part of the root canal along with the accessory canals.

The scale was further dichotomized, with scores of 0&1 as inadequate ingress and scores 2&3 as adequate ingress of the contrast media.

Implication

1. It is important to have a knowledge of the anatomy and development of teeth and mouth in order to maintain good oral hygiene.
2. By understanding normal mouth development and learning to recognize abnormal conditions, we will

be able to spot the early warning signs of problems or diseases.

3. Proper tooth form contributes to healthy supporting tissues hence any abnormality detected early can be treated with full awareness about the condition by the endodontist.
4. This test allows the radiologists to evaluate structures that are not clearly evident on conventional X- Ray exams, X – Rays work by passing through the body.
5. Contrast media enhances and improves the quality of images which leads to better prognosis.
6. This study will also help to analyse or diagnose the non cavitated tooth decay in areas where they are in contact with the adjacent teeth.
7. We can also understand the tooth morphology, root morphology which can be researched further.

INTRODUCTION

- The internal root canal anatomy must be determined as it is used as a basis for the course of endodontic therapy.
- Conventional radiography is an indispensable tool for rapid chair-side visualization of the root canal anatomy, but 3D visualization is not achieved. Thus, methods that can enhance visualization are required.
- Barker et al. first attempted to use an endogram to enhance the radiographic visualization of the root canals using contrast media but, the toxic lead based elastomeric contrast media was difficult to remove from the root canals.

- Water-soluble contrast agents have been used with varying degrees of success.
- Contrast media can be categorized into the ionic type (Monomers: Diatrizoic acid, iodic acid and dimers: ioxaglic acid and iocarmic acid) and the nonionic type (Monomers: Iohexol, iopamidol, iobitridol, ioversol, iopromide, and iopentol and dimers: iotrol, iotrolan, and iodixanol).
- The non-ionic type has lower osmolality and reduced chemotoxic effects and is better tolerated and less viscous than the ionic type

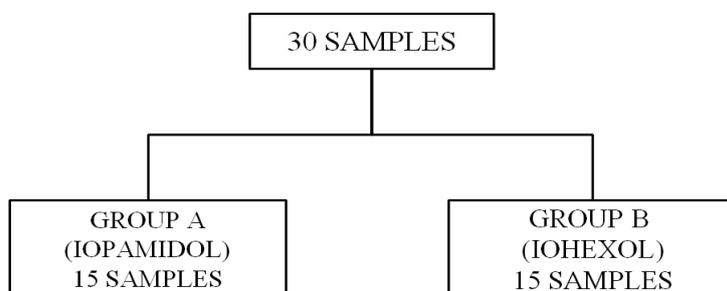
AIM AND OBJECTIVE

- This study aimed to investigate the efficacy of two different non-ionic based contrast media for visualization of the root canal morphology.

MATERIALS AND METHODOLOGY

In vitro experiment

- Sample collection and preparation:- 30 human single rooted teeth with intact roots and mature apices were collected which are extracted for orthodontic reasons from the department of oral surgery according to the university guidelines.
- After extraction, the teeth were immersed in 5.25% NaOCl solution for 30 minutes to remove soft tissue remnants and stored in 0.2% thymol solution until use



Iopamidol

- Non ionic
- Composition: 510mg of iopamidol contain 1 mg of tromethamine and 0.33mg edetate calcium disodium.
- Solution contain approximately 0.029 mg sodium and 200mg organically bound iodine per ml.

Iohexol

- Non ionic
- Composition: each ml of iohexol contain 1.21 mg tromethamine and 0.1 mg edetate calcium disodium with ph between 6.8 and 7.7with hydrochloric acid and sodium hydroxide.
- Also known as Omnipaque.

Iohexol

- Non ionic
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- Also known as Omnipaque.

MATERIALS**METHODOLOGY**

Application and evaluation of contrast media

A single trained endodontist performed the procedure to avoid procedural bias.

In total, 1 mL of each contrast solution was mixed with 0.5 mL of 5.25% NaOCl via electro-stirring.

After access cavity preparation, the contrast media was passively introduced into the pulp chamber using a double side-vented 30-G endodontic irrigation needle.

After 1 minute, RVGs in bucco-lingual planes were performed to analyze the depth of contrast media ingress.

The canal patency was determined using a no.6 K-file (MANI, Utsunomiya, Japan), and coronal third enlargement was performed.

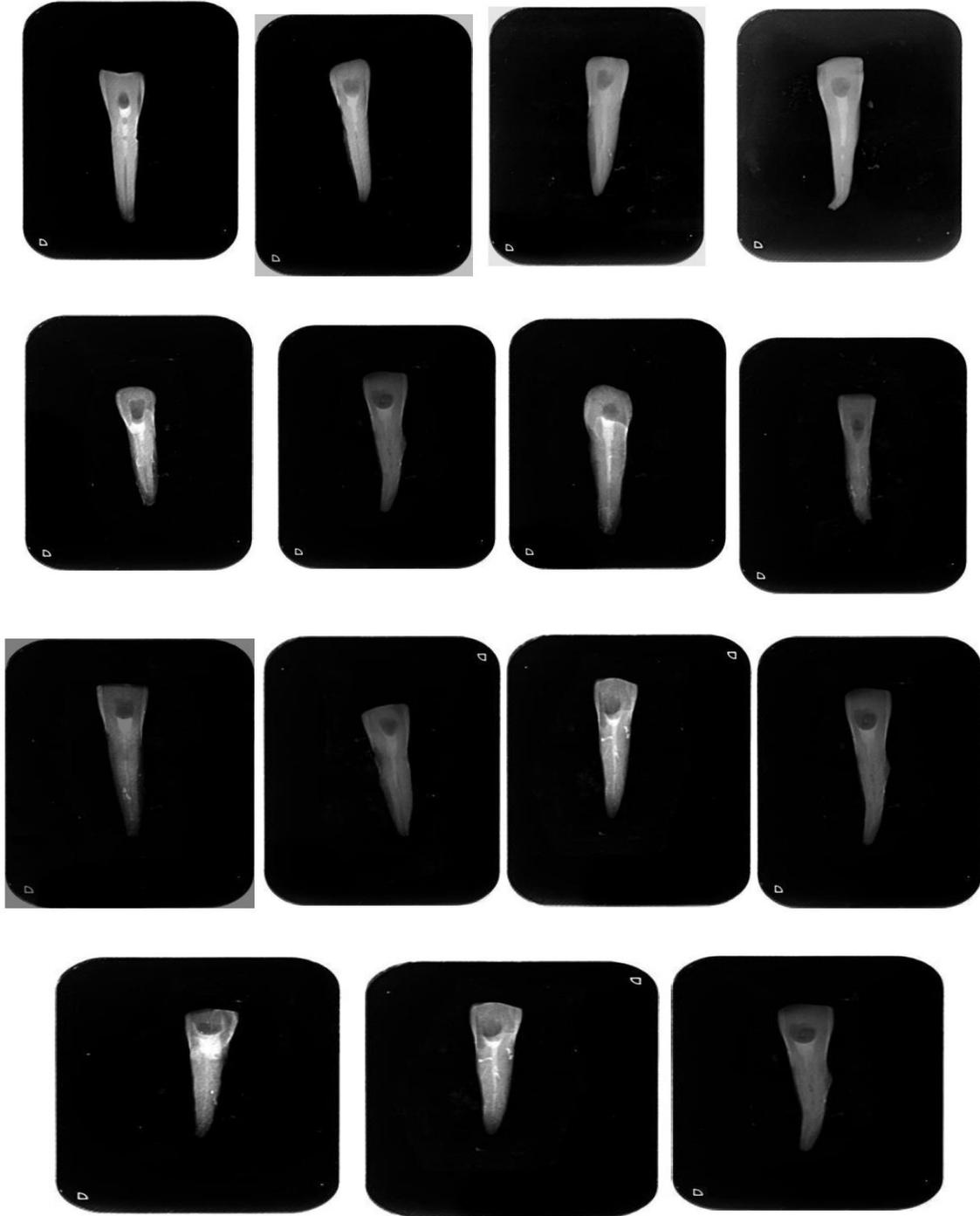
Actual length was determined by inserting a size 10K file into the canal until visible at the apical foramen. Working length (WL) was established.

Canal enlargement was done with the sequential use of K-file (MANI) sizes #8, #10, #15, #20 and #30 up to WL.

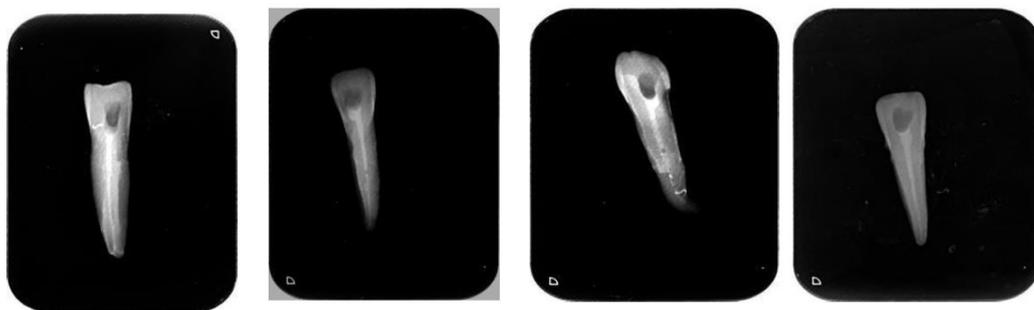
Two mL of 3% NaOCl was used between each successive file size.

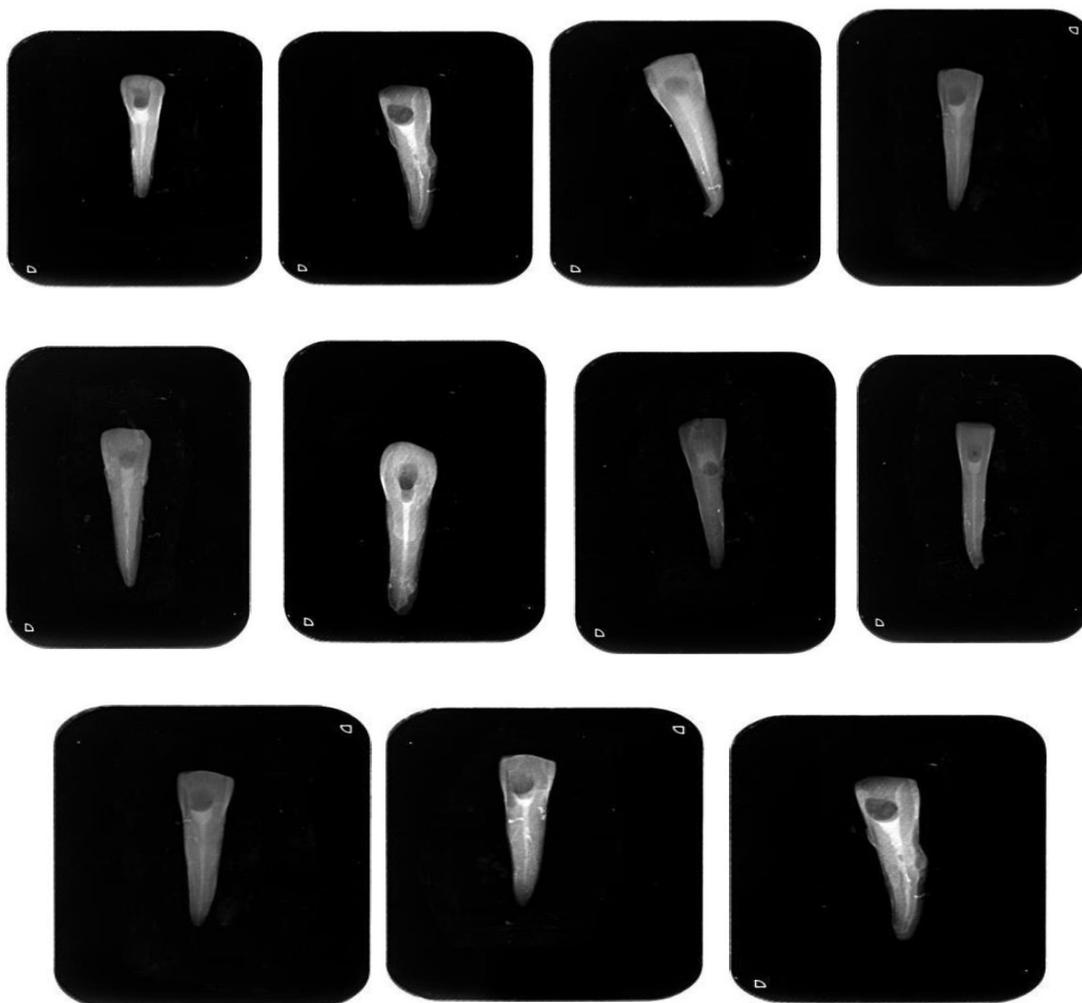
The canals were dried using absorbent paper points and 0.5 mL of contrast media was introduced into each canal using a positive pressure with a double side-vented 30-gauge endodontic irrigation needle and successive RVG was performed.

Group A-Iopamidol: After access opening (15 Samples)

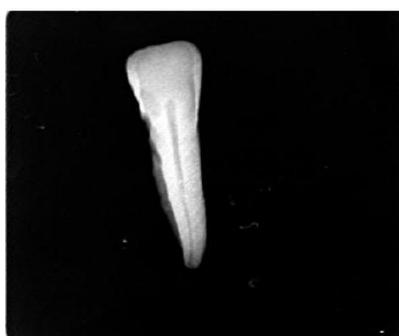


Group A-Iopamidol : After Cleaning and Shaping

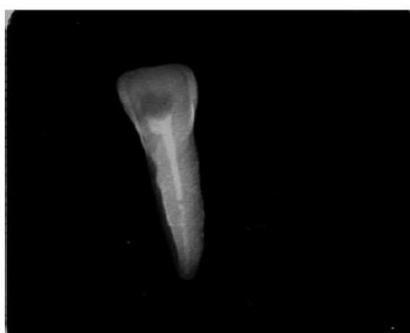




Group A: Iopamidol



Pre Operative X-Ray

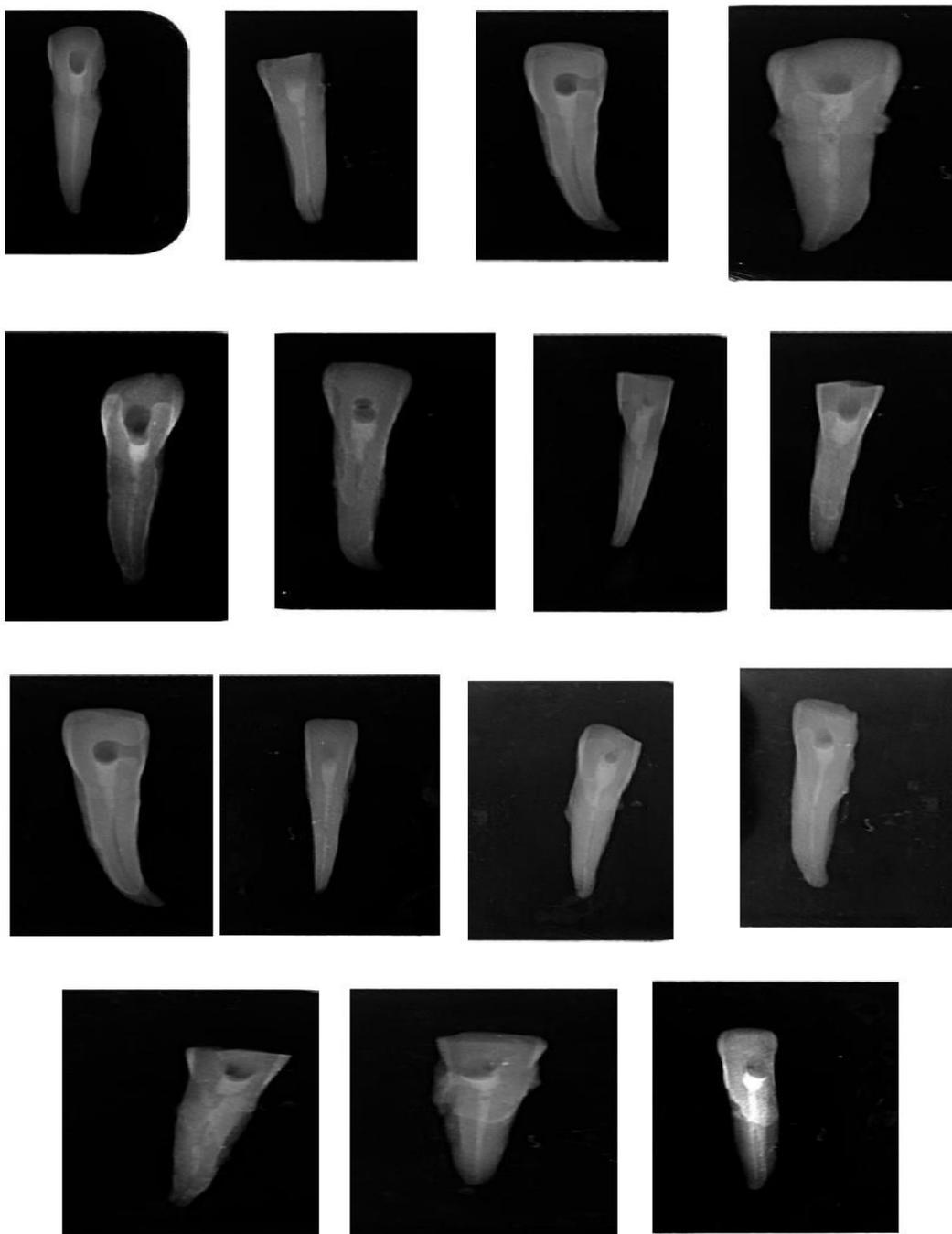


After Access Opening

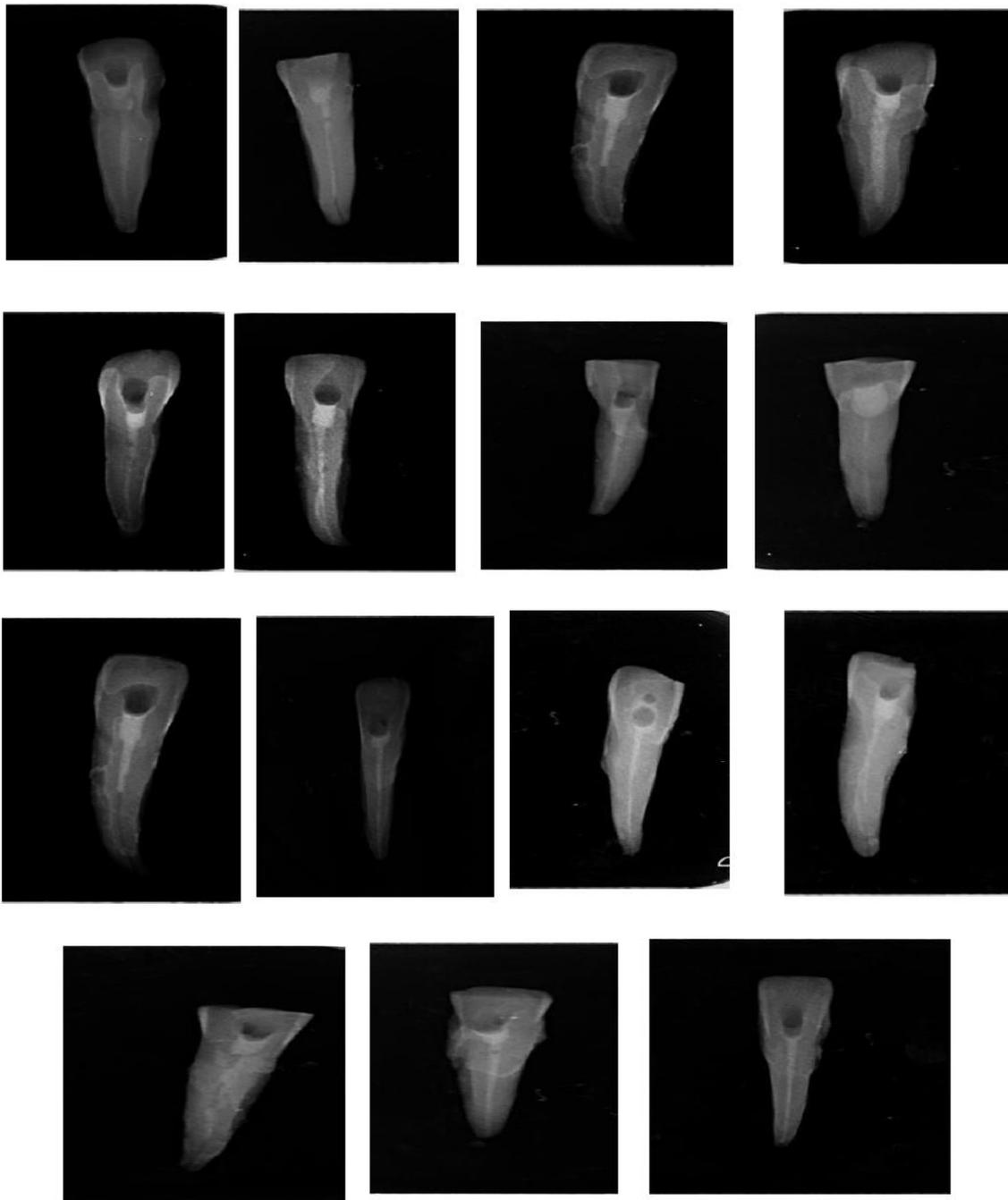


After Cleaning and Shaping

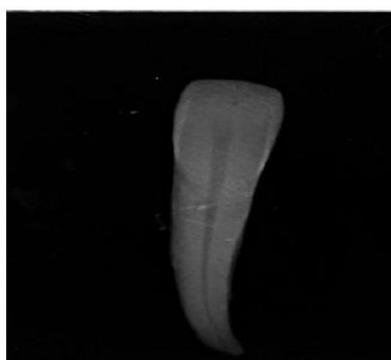
Group B-Iohexol: After Access Opening



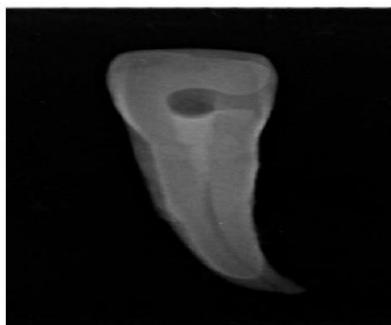
Group B-Iohexol: After Cleaning and Shaping



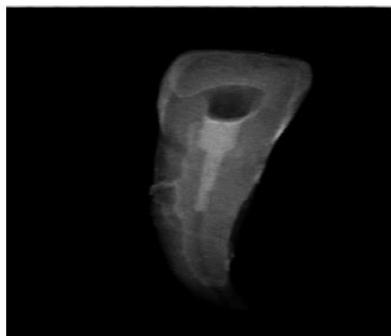
Group B –Iohexol



Pre Operative



After Access Opening



After Cleaning and Shaping

To evaluate the depth of contrast media ingress and to identify the aberrant root canal anatomy, 2 experienced endodontists who were blinded to the study assessed the results using the scoring criteria described in a study.

The scoring criteria for contrast media ingress in the root canals were as follows:

- 0: No radiopacity
- 1: Radiopacity up to the middle third.
- 2: Radiopacity up to the apical third.
- 3: Radiopacity of the apical part of the root canal along with the accessory canals.

The scale was further dichotomized, with scores of 0 and 1 (inadequate ingress) and scores of 2 and 3 (adequate ingress) of the contrast media

Statistical analysis

The Mann-whitney u test was applied for the in vitro study to compare the depth of ingress of the 2 contrast media for the collected samples. The level of significance was set at $p = 0.05$

RESULTS

Based on the inter observer analysis of agreement in the in vitro study, Iohexol + 5.25% NaOCl (groups 1 and 2, $p < 0.05$) had the most significant depth of ingress, followed by Iopamidol.

The ingress of Iohexol + 5.25% NaOCl after access opening is significantly less when compare to after initial cleaning and shaping, the ingress of contrast media to the WL increased and, significant canal anatomy was visualized on the radiograph.

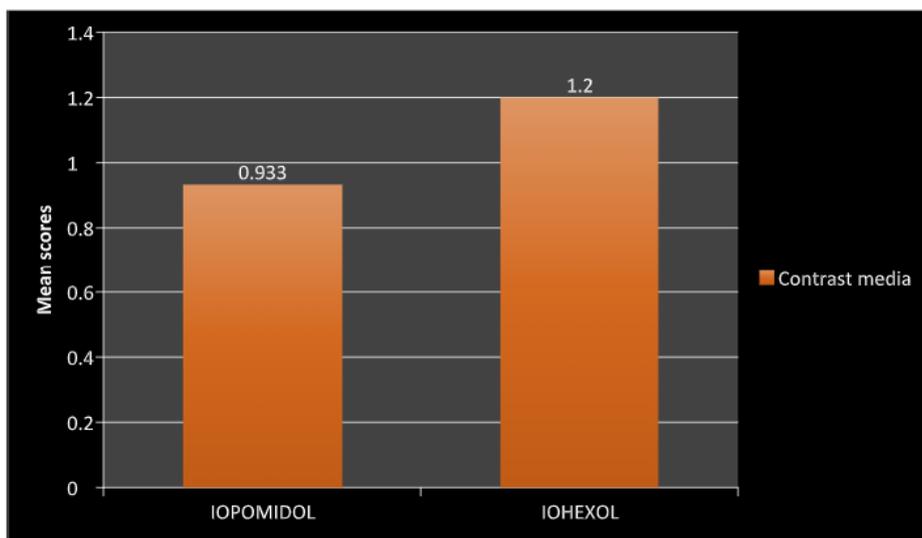
VARIABLE ASSESSED	GROUP	N	MEAN RANK	SUM OF RANKS
AFTER THE ACCESS OPENING	IOPOMIDOL	15	14.13	212.00
	IOHEXOL	15	16.87	253.00
	TOTAL	30		
AFTER CLEANING AND SHAPING	IOPOMIDOL	15	14.33	215.00
	IOHEXOL	15	16.67	250.00
	TOTAL	30		

Table showing Mean and sum of ranks for the two groups

STATISTICAL TEST	VARIABLE ASSESSED	
	AFTER THE ACCESS OPENING	AFTER CLEANING AND SHAPING
MANN-WHITNEY U	92.000	95.000
Z	-.903	-.812
ASYMP. SIG. (2-TAILED) p value	.367	.417

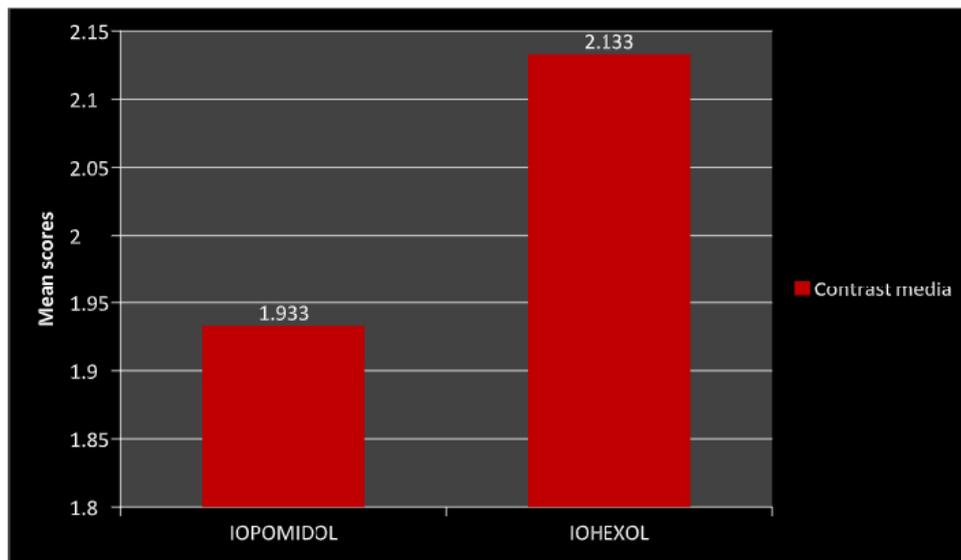
Comparison of scores of two groups

GROUP	DESCRIPTIVES FOR - 'AFTER THE ACCESS OPENING'		STATISTIC
IOPOMIDOL	Mean		.933
	95% Confidence Interval for Mean	Lower Bound	.491
		Upper Bound	1.376
	Median		1.000
	Std. Deviation		.799
	Minimum		.000
	Maximum		2.000
IOHEXOL	Mean		1.200
	95% Confidence Interval for Mean	Lower Bound	.723
		Upper Bound	1.677
	Median		1.000
	Std. Deviation		.862
	Minimum		.000
	Maximum		2.000



Mean scores for values recorded after the access opening based on contrast media used

GROUP	DESCRIPTIVES FOR -'AFTER CLEANING AND SHAPING'		STATISTIC
IOPOMIDOL	Mean		1.933
	95% Confidence Interval for Mean	Lower Bound	1.544
		Upper Bound	2.323
	Median		2.000
	Std. Deviation		.704
	Minimum		1.000
	Maximum		3.000
IOHEXOL	Mean		2.133
	95% Confidence Interval for Mean	Lower Bound	1.779
		Upper Bound	2.488
	Median		2.000
	Std. Deviation		.640
	Minimum		1.000
	Maximum		3.000

**Mean scores for values recorded after cleaning and shaping based on contrast media used****DISCUSSION**

- X-ray contrast media (CM) are generally compounds or formulations used for a variety of imaging diagnostic radiology procedures.
- An ideal CM would have the maximal object contrast attenuation of X-ray and measure the difference in attenuation between that object and its surroundings. Other criteria for an ideal CM are that they should have no side effects and have been developed into safe imaging agents, so the primary criteria for safety are that they are excluded from cells and stay extracellularly, do not undergo metabolism and are chemically stable. To achieve an ideal CM, efforts were aimed at increasing attenuation and minimising side effects by changing their physical and chemical properties {cf. Almen, 1995}.
- The use of contrast media and endo-radiopaque solution during intraoperative digital radiography has been considered effective in determining the root canal anatomy.
- In vitro, the absence of pulpal tissues in the pulp chamber and the root canal resulted in a greater ingress of contrast media solution.
- Compared with ionic media, non-ionic contrast media can be easily delivered due to low osmolality and less viscosity.
- In terms of disadvantages, ionic contrast media causes discomfort and, individuals can feel the heat sensation during injection due to high osmolality,

cytotoxicity of the agent and, increased pressure requirement during injection.¹

- In clinical settings, calcifications in the pulp chamber and root canals, constriction of root canals and, increased volume of pulpal tissues in the chamber must be considered, which might prevent ingress of the solution.^[1]
- Iodinated contrast media are of two types, Ionic and nonionic. Ruddle's solution, containing ionic medium, and Saigram, containing non-ionic medium, have been successfully used clinically in combination with chelating agent and organic tissue dissolving solvent, in the form of an irrigant.^[2]
- Ionic contrast media have i) high osmolality which causes sensation of heat and discomfort, pain and potential irritation, if it extends beyond the apex, ii) high viscosity which requires more pressure to flow. Non-ionic contrast media are low in osmolality, less chemotoxic, better tolerated and less viscous⁸. Katayama et al observed four times reduction in the adverse reaction in non-ionic contrast media.^[19]
- Iopamidol and iohexol has been adopted for endodontics in this present study. It is a non-ionic contrast medium, which has already been used in angiographic procedures in the medical field.^[20]
- The current in vitro study indicated that Iohexol + 5.25% NaOCl ($p < 0.05$) had the greatest efficacy, followed by Iopamidol.
- The root canal anatomy can be accurately assessed using a radiographic angulation of 0° – 30° .
- Based on this criterion all RVG's in the present study were taken within this range for assessing root canal anatomy.
- The sensitivity of the intra-rater reliability improved with the use of the zoom, inverse, and revealer options in the RVG software. Hence, the Kappa analysis of agreement indicated a high standard of agreement (> 0.61).

CONCLUSIONS

In the current study, the use of Iohexol to visualize and understand the intricate canal anatomy for endodontic treatment via RVG was found to be effective.

Future research using Iohexol can be conducted regarding the cleaning efficacy of the organic and inorganic debris from the root canal and to determine the clinical incidence of accessory and/or lateral canals clinically.

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