

# Introduction of Digital Microscope and Near Eye Screens with Augmented Reality and Virtual Reality in Regular Dental Procedures

Danie Shammy\*, Samuel Jeyakaran, Jeyanth K Newport

Department of Public Health Dentistry, Madras Medical College, Tamilnadu, India

## Research Article

**Received:** 30-May-2023, Manuscript No. JDS-23-100680; **Editor assigned:** 01-Jun-2023, Pre QC No. JDS-23-100680 (PQ); **Reviewed:** 15-Jun-2023, QC No. JDS-23-100680; **Revised:** 25-Aug-2023, Manuscript No. JDS-23-100680 (R); **Published:** 01-Sep-2023, DOI: 10.4172/2320-7949.11.4.004

**\*For Correspondence:** Danie Shammy, Department of Public Health Dentistry, Madras Medical College, Tamilnadu, India; **Email:** [jeyanthnewport@gmail.com](mailto:jeyanthnewport@gmail.com)

**Citation:** Shammy D, et al. Introduction of Digital Microscope and Near Eye Screens with Augmented Reality and Virtual Reality in Regular Dental Procedures. RRJ Dent Sci. 2023;11:004.

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## ABSTRACT

Usage of VR (Virtual Reality) in Dentistry is limited to patient wearing the viewer to see a video to calm one down while undergoing fearful dental procedures. But it was never worn by the dentist himself, to view and do the dental procedure. The main principle of the study is to increase the magnification of the restricted area of oral cavity using a digital microscope. Digital microscopes of 2 megapixels and 5 megapixels, were used by the authors to view dental procedures while doing through smartphone supported Augmented Reality (AR) and Virtual Reality (VR) glasses. It is important to note that using digital microscope in doing regular dental procedures viewing through AR/VR glasses were so far not reported. But we were careful in establishing the success of this new concept and are delighted to share for further advancement. At the same time, there are bottlenecks which are listed as limitations that can be further modified for success, which has to be developed by the manufacturers involved in research and manufacturing of dental equipments. Hence this article envisage the dental chair manufacturers should roll out every dental unit with built in maneuverable digital microscope, software and near eye screen that will be a boon for the patient and the dentist.

**Keywords:** Augmented reality; Virtual reality; Megapixels; Digital microscope; Smartphone

## INTRODUCTION

Doing routine dental procedures evoke musculoskeletal disorders in dentists and up to 80% of dentists who are practicing for more than 20 years are affected by these disorders. While doing dental procedures, dentists are required to encompass most of the following.

- Working in a small restricted area.
- Difficult access areas.
- Good and clear vision.
- Coordination of vision and manual dexterity.
- Manual control, while working with high precision and cutting instruments.
- Operatory postural stillness and stiffness for many hours.

Dentists are expected to cope with these stresses by rigorous training, developing skills, increased concentration, devoting their energy to withstand, but at the same time they oversee the fatigue and strain caused while practicing the dentistry. Due to rigorous strain, the postural ergonomics is being affected <sup>[1]</sup>.

Dentists ruin their back and fails on posture, because they strain to get better visibility of the field area. If we improve the visibility of the restricted work area by magnification, zooming and good lighting and give a bird's eye view on a head mounted display or near eye display (smart phone based) then a comfortable position can be maintained by the working dentist and his/her posture is unaffected. Also, apart from dentist, procedures are performed unerring with more accuracy benefitting the patient. So, digital magnification with near eye vision is a useful tool in dentistry which is an emerging field in dental science <sup>[2]</sup>.

### Principles of the study

- By increasing the magnification of the restricted area of oral cavity by using a digital microscope as shown in Figure 1. A digital camera acts as a detector. Images are displayed on a screen, turning the microscopic view station into an ergonomic digital workplace.
- By using the maneuverable arm as shown in Figure 2, the digital microscope is adjusted to be at the required position. Dentist or assistant use their hands instead of turning their head or neck, to focus the view of the difficult access area, in a comfortable position without giving strain to their body <sup>[3]</sup>.

**Figure 1.** Digital microscope.



Figure 2. Maneuverable arm to fix digital microscope.



- By viewing the area of work through a near eye screen viewer (mobile phone) attached near dentist's eyes by sitting in a comfortable position as demonstrated in Figure 3.

Figure 3. Demonstrating the functioning of digital microscope.



- The dental procedures are performed at ease, with clarity and without exerting stress and strain to the body.

## MATERIALS AND METHODS

### Methods

Our team of researchers did not go through the high end preparation of buying Google enterprise smart glasses (approx.. 999 USD), the compatible digital microscope and gas spring maneuverable arm, to incorporate in this study, which would have made things easy, but it is not economically viable [4]. So, the research team restricted in simplifying the device to common digital microscope, smartphone based augmented reality and started experimenting simple dental procedures as demonstrated in Figure 4. As our simple AR and VR experiment provided with results in performing dental activities, it is in our scope that all dental procedures can be performed with more accuracy and simplicity by using these devices [5].

Figure 4. Smartphone based augmented reality.



Digital microscope does not have an eyepiece and use a digital camera as an eyepiece. The digital camera is the detector and the image output device. The display of the image is done on a computer screen or monitor that run through software or an app. The microscope's light source is an inbuilt Light Emitting Diode (LED) [6].

AR (Augmented Reality) can be defined as a system which

- Gives a combination of optical (natural vision) and digital (virtual) world.
- Real time interaction (with latency).
- Digital view of magnified work area and objects (zooming).
- Vision of surroundings, patient face, instrument trays etc. (bird's eye view).

VR (Virtual Reality) can be defined as a system which

- Replaces dentist's real world environment (optical/natural vision) with a digital (virtual) one.
- Real time interaction (with latency).
- Accurate registration of Magnified real objects.
- Concentrated digital view of only what the microscope focus.

## Materials

Our research team used the existing infrastructure of our clinic and also the cost effective tools for this AR and VR experiment that proved to be a success. The simple materials used for this study are given below [7].

## Attachment area

- Dental chair head rest adjustment arm.
- Operation tray arm.
- Dental light arm.

## Gadgets

- Light weight smart phone, low Specific Absorption Rate (SAR) and microscope app.
- Digital Microscope 5 MP camera with Focal Length (FL<80 mm, fps 30+).
- Near eye headset viewer (AR glasses).
- VR case for smartphone.

**Attachments**

- Quick lock stand (bracket to attach to the required arm).
- Swivel arm with lock.
- Boom arm or serpent arm with smooth 4 axis movement.
- Clip to hold microscope.

Our research team used a dedicated smartphone (Nokia C3) of appropriate size for the AR viewer with On The Go (OTG) cable and application to support the microscope and used a bluetooth navigator/controller. There was no sim card (subscriber identity module) inserted inside the smartphone during the experimental study.

**Experiment**

Our idea of using AR and VR is the outcome of the COVID lockdown, as our Government strictly banned opening of dental clinic to reduce the spread of the variant. Regular procedures were postponed or cancelled, considering the proximity of the dentist to the oral cavity, as the profession needs close contact with the patient that is inimical for both, if affected by the virus. So our team used IO cameras to diagnose, and then migrated to an old exoscope with 2 MP camera with 70 mm Focal Length (FL) to do the dental procedures using digital screens. More adjustments with different angles, screens, near eye glasses were attempted. Doing procedures with mild variation of 15–20 degrees to the regular eye position provided better results in performing the dental procedures. Soon, with long focal length 5 MP digital microscope, with good maneuver ability, accuracy, comfort and desired speed was observed during the experimental dental procedures.

Visibility is a prime factor in dentistry whether in diagnosing or treatment. Through history, devices had been added on to dental equipment list to aid the clinician. The magnifiers used in dentistry are given below and the specifics and problems of using the magnifiers are given in Table 1.

- Magnifiers
- Loupes
- Dental Operating Microscope ( DOM )
- Procedure scopes
- Intra oral camera
- Digital scanners
- Digital microscope

**Table 1.** Specifics and problems using magnifiers.

Mode	Magnification -X	Examination	Procedures	Posture of dentist while performing dental activities	Strain during dental procedures	Cost of magnifier (INR)
Naked human eye	0	Yes	Yes	<40 degree at neck	Yes	0
Magnifiers	3.5X	Yes	Yes	<40 degree at neck	Yes	<5,000
Loupes	5X	Yes	Yes	<25 degree at neck and fixed head position	Yes	<10,000
Surgical operating microscope	20X	Yes	Yes	<10 degree at neck and fixed head position	Mild	<15,00,000

Procedure scopes	25X	Yes	Yes	Fixed position of head and neck on mounted screen	Mild	<8,00,000
Intra oral camera	25X	Yes	-	Fixed position of head, neck on mounted screen	-	<25,000
Digital scanners	25X	-	-	Fixed position of head and neck on mounted screen	-	<10,00,000
Digital microscope with near eye screen using AR and VR cases	5X-50X	Yes	Yes	Head and neck in neutral position	Minimal	<50,000

Of these, Loupes and operating microscopes are useful during dental procedures but causes some head and neck strain as they are not digital. Digital scope, EZ scope 4 is used for dental procedures and they are digital, but fixed, and also cause some strain while working on dentistry. They are under development right now, and are expensive too. On the other hand Digital microscopes with AR viewer and smartphone procedures can be viewed through, magnified, recorded with the comfort of the dentist without much strain and at affordable cost (Figures 5 and 6).

Figure 5. Loupes and operating microscopes.



Figure 6. Digital and EZ scope 4.



**Adaptation curve (time consumption)**

As it was a trial experiment using locally available gadgets, we encountered problems during the initial phase for alignment with our dental work procedures. Hence, till passing the learning curve (adaptation curve), much time was wasted. But after passing the learning curve, time taken for each dental procedure was reduced considerably. While in adaptation curve, following bottlenecks are noted.

- Since microscope aiming was difficult during the initial phase of the dental works, much time was spent on adjustments, but just after a few trial procedures, adjusting the scope became familiar.
- Focusing was needed when shifting from anterior to posterior or vice versa, and either the Dentist or Assistant has to look into that focusing position of the device.
- Dental overhead light was not required when doing a particular area on tooth thereby making the vision comfortable.
- Dental assistant has to be trained to do the maneuverability, focusing and recording of the procedure as and when needed. (Additional fixed screen is being added for the sake of visibility for the assistant).
- Our experience revealed that the time taken for each procedure has been reduced considerably during the dental procedures by using this method.

**Cross contamination**

Since the digital microscope head has inbuilt Light Emitting Diode (LED), it is not submersible, or auto clavable but gentle wipe with disinfectant was done. Boom arm and near eye headsets and all surfaces were also wiped up with disinfectant to avoid any cross contaminations. Autoclaved surgical covers were used at times of surgeries only.

**VR/AR glass case comparison**

When virtual reality case with smartphone was worn, more of blocking the “outside world view feel” was experienced. But for doing concentrated Root Canal Therapy (RCT) or crown preparation procedures, this was very much comfortable in using the dental procedures. Eye adjustment was needed after the removal of Virtual Reality (VR) case, a mild blurred vision was noted more in comparison with Augmented Reality (AR) case.

Handling of instruments proved tricky and assistant has to be well trained to place every instrument in a routine pattern as and when needed. Both these models of VR and AR yielded good results in performing the dentistry work, in their respective usage. But doing the procedure, interacting with patient, communicating with assistant all seemed a step above and harder when fully covered VR case was used. Doing the same with AR case was relatively easy while using these gadgets.

The limitation of our experiment using AR/VR and also the suggested corrective measures are given in Table 2.

**Table 2.** Limitations and corrective measures.

Limitations	Corrections to be made (R and D)
Battery running down after 4 to 5 hours	Both the microscope and the near eye screen need external batteries, and get power supply from the dental unit itself.
Latency or snag	Microscopes with Focal Points of 60 or more is needed.
Auto focus of the digital microscope	Microscope needs to be developed for the purpose of “digital oral health imaging” and add a sensor for auto focus. Or foot controlled focusing can be developed.
Adaptation curve for accepting the,	Dentist and assistant needs to be patient and persuasive.

digital microscopy, AR and First Person View (FPV) for procedures	Introduction and training in dental colleges is needed to implement this technique.
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**Observation**

While visualizing the procedures digitally, and starting to do them, other advantages were also noted. One of them is angled view of work area, giving perspective view. Another advantage is one can directly see the UV light of light cure unit on screen and it does not need filter. So again work area visibility while doing procedures is exemplified.

Also, as the technology is advancing daily, one have to get the latest affordable digital tool. This is tricky as there is no limit to the high end/expensive near eye glass of augmented reality. Near eye glass view is better than a screen fixed on the wall view, to the dentist, for doing procedures. A study confirms this future Dentists can use this tech and be adaptive to do dental procedures digitally.

**Analysis**

- Is it not acceptable that a combination of digital microscope, some augmented reality, and digital storage comes affordable and cheap to every cost friendly dentist? It is good to bring in the concept of digitalizing the procedures and treatments using digital microscopes, software applications and AR glasses.
- Is it not appealing to magnify the teeth and gums so that our finished dentistry work quality is best seen? It is also good to encourage our clients by giving them a pre and post-operative magnified image just to motivate them for better oral care.
- Is it not good that we think about dentists to protect our backs and necks in health aspects, to be freer rather than bend our heads to get a better view? It is best to conveniently posture ourselves in comfort, while we treat our patients.

It is recommended by the author that dental chair manufacturers should roll out every dental unit with built in maneuverable digital microscope, software and near eye screen.

**RESULTS AND DISCUSSION**

Using digital microscope with near eye smart glasses or AR is not a replacement of naked eye vision, to be used in diagnosis or procedures, as all dentists are trained and sharpened their skills with naked human eye.

But digital microscopy and AR glasses is a useful tool, aiding dental surgeon in doing them better. Near eye glasses (AR) in neurosurgery, general surgery, orthopedic surgery, ophthalmology, and cardiovascular and thoracic surgery have been proved successful and promising. Digital microscopy and near eye glasses (AR/VR) also gives lesser strain to the dentist. While doing regular dental procedures, using digital microscopes, and near eye headset (AR case with smartphone) gives a better outcome to both dentist and his client.

Looking ahead, maybe with introduction of maneuverable robotic arm with voice commands and powerful auto focus digital microscope, it may replace the naked eye vision to do dental procedures in future.

## CONCLUSION

Technology is out there. Even drone flyers, laparoscopic surgeon, ENT surgeon, have incorporated digital view, magnified/zoom view, and FPV of their work area to aid in their profession. In dentistry, for doing dental procedures, surgical operating microscope and dental loupe which are in use is promoted. It is high time, in this digital era, dental fraternity should start to use digital microscopes and near eye screens (AR) for every dental procedures as an easy, affordable and better way, to benefit all dentists and their clients.

## ACKNOWLEDGEMENT

We are thankful to the almighty for making this experiment a success by using cost effective, locally available gadgets and we want to give the technology transfer to the manufacturers of Dental equipment and devices so that they can avoid cost of patency, thereby avoiding charging additional cost on the economically marginalized communities who are using the service of dentistry.

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