



Prevalence of Dental Implant in Adult's Orthodontic Patients with Oral Radiological Point: A Systematic Review

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ABSTRACT

In the present study, the prevalence of dental implants in adult orthodontic patients with oral radiology was examined by reviewing more than 45 articles. Implants are one of the dental implantation techniques that has its own supporters today. However, the beneficial effect of implants depends on several factors, one of which is the selection of the appropriate imaging method. With the advancement of science and technology, imaging has also found its own methods that are used according to the type of operation or diagnosis of the doctor. Among other things that are discussed about the effects of implants under radiology is the selection of one of the types of radiography. It is interesting to know that radiology has different types, which are considered as conventional radiography (CT) or cone beam computed tomography (CBCT). Each of these techniques can provide specific information to the doctor. So, considering these points in the field of implants, one of them is selected. In this process, imaging helps the doctor to make the right intervention in placing the implant on the bone in relation to the surrounding structure. Also, with a correct understanding of the situation, it creates a path for surgery that makes everything safer and more secure and minimizes surgical complications. Since the implant is a prosthesis with an additional structure in the mouth, it must be done in line with the set goals. The results of the present study showed that the prevalence of peri-implantitis is more observed in people with an older average age. Also, systemic diseases are a protective factor for peri-implantitis.

Introduction

Implant imaging is one of the most important measures before performing this surgery. This is done with the aim of measuring the patient's tolerance to this surgery. It is also used to identify bone pathology, its depressions and bone density assessment [1]. Of course, the time and type of radiology depend on various factors, but in general, it is done in several stages, which we have examined below:

A) Preoperative imaging: If we want to follow this stage with the example of building architecture, we should say that this stage is related to estimating the resistance of the ground, considering the required

materials, and also identifying the appropriate foundations to start the work [2].

In fact, this phase is considered an introduction to implant surgery. Dental implants under radiology give the doctor the information he needs to start his work. For example, the quantity and quality of the bone, estimating the location of the implant, and in general, information related to the implantation of this prosthesis are all obtained at this stage [3].

So you cannot perform implant surgery without it. The information obtained in this way is:

- 1- Measuring the height and width of the bone.
- 2- Assessing the quality of the bone.
- 3- Determining the long axis of the alveolar bone.
- 4- Identifying and localizing the internal anatomy.

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- 5- Establishing the boundaries of the jaw.
- 6- Detecting any underlying damage [4].

B) Intraoperative imaging: Since the mouth is a place that is not easily visible to the doctor, intraoperative imaging helps to see if everything is going according to the first phase. In fact, this process is like creating a monitoring of the correct progress of the implant surgery process, which greatly contributes to its effectiveness. Placing the prosthesis in the right place, the distance from other teeth, and trimming it to the extent that it fits over other teeth are among the things that are observed in this stage [5].

C) Post-dental implant imaging: From the time the dental implant is performed under radiology until the implant remains in the jaw, they are in this stage. It is possible that this prosthesis will need modifications that will be followed by radiology. So it can be placed in the post-surgery category. Also, bone assessment or prosthesis maintenance can be used at this stage. It does not matter if you had your implant surgery a few minutes ago, or a few years ago. In both cases, you should use radiology to review this process [6].

Types of Radiology Methods for Implant Surgery
Now that you are familiar with what radiology is and how it is used in implants, you should know what methods are used by doctors for this task. We have reviewed these methods below:

1- Cephalometric radiography (a specific and specific range): If your doctor wants to follow the dental implant under radiology with the aim of obtaining a cross-sectional image of the jaw, this method will be highly suitable for it. This helps to both ensure that the aesthetic process is carried out correctly and provides more accurate information about the position of the prosthesis or the structures around it. The most common use of this type of radiography is before implant surgery, to provide the doctor with detailed and accurate information. So don't be surprised if your doctor sends you to radiology centers for a cephalometric radiography before the operation. This method is also suitable for patients who have completely lost their teeth. Because it can well evaluate the bone height, the inclination of the anterior teeth in the prosthesis and the soft tissue profile [7].

2- Panoramic radiography (creating an image of two jaws): Another method that is widely used in dental implants under radiology is panoramic radiography. It is interesting to know that both films and photographs can be prepared in this method. These films and photographs include both jaws and provide the doctor with interesting information

about the location of the implant for the jaw to adapt to each other. In addition, due to the thickness of this device, the distance between the teeth and the implant site is clearly visible, which can give the doctor good information about the patient's current condition even during surgery. Because it has an inherent magnification that will be useful for the doctor during surgery [8].

3- Digital radiography (possibility of changing based on shadow creation): Among the methods used in the field of dental implants is digital radiography. In this method, the received image can be changed in various ways and converted into personalized information for the doctor. In this, computer programs and software play an important role. The most common use of this method is during the operation stage. Because it creates and delivers the image instantly. It also depicts different parts of the mouth, such as bones and their structures, in different colors, so that the doctor can identify them better and more clearly. Therefore, digital radiography will be very useful in the field of dental implants under radiology [9].

4- Conventional tomography (imaging from a specific angle): Among the cases used in implant surgery under radiology is conventional tomography. This radiology can examine a specific angle completely and comprehensively through the extension of the laser and in this way provide information about the tooth and the location of the prosthesis to the surgeon. This method also has a uniform and appropriate magnification factor that depends on the distance of the device to the object. That is, the doctor can determine a specific angle for imaging and thereby directly evaluate all the structures in that section. Therefore, it is a suitable method for surgeons during surgery, so that they can access an angle and blind spot that cannot be seen with the conventional method. In this method, if the device is placed close to the mouth, there is a possibility of blurring and lack of clarity of the image. Therefore, the choice of radiology center also plays a fundamental role in this process that cannot be ignored [10].

5- Spiral tomography (creating spiral motion of rays): Another method available in the field of dental implants under radiology is spiral tomography, which also helps doctors in recognizing diseases of the mouth and jaw. In this technique, blurred shadows are placed at specific and coordinated distances from each other, so that topographic images are obtained using the spiral motion of the rays. You can certainly guess how detailed and complete the information obtained from this image can be. Among the advantages of this method is the creation of 4 different images at one angle, which leaves no room for doubt in the doctor's

diagnosis process for the location of the implant. Each film shows a 16 mm section of the upper or lower jaw, which is created with four exposure processes. In general, this method helps to determine the spatial relationship between vital structures and the implant location, to follow the mental integrity of the image [11].

6- Computed tomography (precise imaging of the implant location): This method is what is commonly used in the process of various surgeries. Computed tomography or CT was invented in 1972. This image can provide useful information about the temporomandibular region and oral and jaw lesions in diseases such as genetic abnormalities. This method is used both to examine the desired indicators before the operation and to examine its effectiveness after the operation. In general, if your doctor needs to analyze the exact location of the implant, he can benefit from this method. Among the

advantages of this method are determining the quality and quantity of bone and identifying key structures around the implant [12].

7- Cone Beam Computed Tomography: One of the most important advances in mankind can be considered the exploration and discovery of cone beam computed tomography. In addition to the effectiveness of implants under radiology in this way, this tool can easily play a role in diagnosing and determining the treatment process of oral and jaw diseases. CBCT is also a powerful tool for creating less noise in the images and a clearer and more obvious configuration. This may not seem like much, but it makes the implant surgery process easier for a doctor, making it both easier to do and increasing the success rate [13].

Table 1. Comparison of different methods in the dental implant process under radiology (investigating the results of implant effectiveness with radiology)

Cephalometric radiography	Low and limited clarity	Limited and linear beam	Bone height assessment
Panoramic radiography	Low and limited clarity	Limited and linear beam	Provide images of both jaws
Digital radiography	Adequate clarity	Single-dimensional beam	Measurement of various indicators in implant placement
Spiral tomography	Adequate clarity	Complex and multidimensional beam	Determine the spatial relationship between vital oral structures
Computed tomography (CT)	Flat and geometric clarity	Increasing the efficiency of X-rays	Detect the structure around the implant and its location
Conical cone beam tomography (CBCT)	High image clarity	Correcting beam	Diagnose types of oral and jaw diseases and implant placement angles

Discussion

For years, it has been considered as the most common method of micro leakage investigation. In this method, the restored tooth is placed in the paint and the paint will penetrate through the seam between the material (restoration) and the ivory walls. Of course, it should be noted that in order to check the micro leakage of the rest of the tooth surfaces, up to one millimeter of the restoration margins should be flooded in order to prevent the penetration of color from other parts of the tooth and to measure the actual leakage of the restoration material [14].

Then the tooth is divided lengthwise into two pieces and the depth of dye penetration is measured and recorded. Its advantages are simplicity, convenience and cheapness. It is also useful for comparative studies. One of its disadvantages is the semi-quantity of information. Also, this method is destructive and as a result the sample is lost and it is not possible to re-measure micro leakage in the long term. The cutting axis is also chosen randomly, which may not determine the place where the most color penetration has occurred [15-17].

1- Marginal adaptation: By SEM, the gap between the walls of the dentin and the filling material is checked. Also, the flow of matter into the dentine tubules is determined. One of its disadvantages is that it is not a quantitative method and does not show the adaptation of two levels in three dimensions, and also the processing steps can cause the filling material to separate from the tooth and cause errors [18].

2- Fluid filtration: Derkson and colleagues in 1986 described an in vitro system for measuring the adequacy of restoration-dentin flood, which measured dentin permeability before and after filling with various materials in general. This permeability is expressed by measuring the amount of liquid that passes through the studied areas per unit of time. This method has been used in several studies to determine the adequacy of flooding of different materials [19].

In 1988, Pashley used it to evaluate the flooding of temporary filling materials. In this method, the restored tooth is connected to a micropipette filled

with liquid after flooding the edges of the restoration, and a small bubble is created in this liquid to check micro leakage [20].

The whole system is put under constant pressure and the amount of bubble movement, which indicates micro leakage, is expressed as $\mu\text{l}/\text{Min}/\text{CmH}_2\text{O}$. This technique is a quantitative method. It does not destroy the tooth and the assessment can be repeated over time; thus, it is suitable for longitudinal studies. Most of the results are recorded automatically. The results are very accurate and very small volumes can be recorded. Several pressures have been used in different studies, which vary from 15 to 1406 CmH_2O . This method has a very high accuracy and one of its advantages is the possibility of re-reading the samples due to the recording of the bubble movement. Another advantage of this method is to increase the speed of the examiner's action, because only a fraction of a second will be required to record the photo in the determined time periods [21].

3- Dye extraction using spectrophotometry:

Another method is to measure micro leakage, in which the teeth are kept in a dye such as methylene blue for 48 hours. In this method, just like the dye penetration method, only the restored area where micro leakage is to be measured is not flooded, but the rest of the area is flooded with a covering material such as nail polish. After 48 hours, the samples are taken out and the covering material and paint are removed. It is washed and then each sample is placed in a special vial of $1\mu\text{l}100$ concentrated nitric acid (wt65%) for 3 days and then the vials are centrifuged at 14000 rpm for 5 minutes [22].

After that, $1\mu\text{l}100$ from the solution of each vial is taken and the absorbance of the dye is read with a spectrophotometer at a wavelength of 550 nm. In this way, according to the amount of color absorbed at the wavelength of 550 nm, the amount of repair micro leakage is determined. One of the disadvantages of this method is that it is a destructive method and the sample is destroyed, and it is not possible to measure micro leakage again in the long term [23].

In 2001, Juergen Manhart et al evaluated the marginal quality and micro leakage of class five adhesive restorations. The purpose of this in vitro study was to determine the edge quality and flood rate of class V composite restorations. Standard class five holes with a diameter of 4 mm and a depth of 2 mm were cut in 90 extracted human molar teeth, so that half of the cutting end of the holes was inside the dentin and was limited to the dentin only. The samples were randomly divided into 9 groups of 10. After etching the enamel and dentin, the holes were repaired with 9 different adhesive systems, using the wet-bonding method [24].

After finishing and polishing, the teeth were stored for 24 hours in distilled water at 37°C and then thermocycled for 100 cycles at $5-55^\circ\text{C}$. SEM was

used to evaluate the repair edges and dye penetration method was used to evaluate micro leakage with a score of 0 to 3. The results of the study showed that statistically, there was a significant difference between the groups in dentin and enamel margins for both micro leakage and marginal quality. In SEM, the Syntac Single-Component/Tetric Ceram group showed significantly higher healthy and perfect edges than the Onestep/Aeliteflo and Solo Bond M/Arabesk groups [25].

In the Aquaprep+Onestep/Aeliteflo group, more leakage was observed in the enamel than in the other groups. None of the studied restorative systems achieved complete flooding in enamel and dentin in class five cavities. Marginal quality and flooding ability of adhesive systems in dentin is still lower compared to enamel margins.

In a study conducted by Yazici AR et al. in 2002, the effect of common bonding systems on micro leakage of composite resin restorations was investigated. The aim of this study was to determine the micro leakage of common dentin bonding systems in class II composite resin restorations.

Class II cavities, 2 mm more apical than the CEJ, were carved on 70 extracted healthy human premolars. The teeth were randomly divided into 5 groups with different bonding systems. All holes were repaired with a posterior composite and thermocycled at 200 rounds. After immersing the teeth in 0.5% fuchsia for 24 hours, they were cut longitudinally and observed with a stereomicroscope to evaluate dye penetration. The results showed that there is no statistically significant difference between the bonding systems in the amount of micro leakage in the occlusal walls. But for the gingival walls, there is a statistical difference between the Clear fil SE Bond group and the Prompt-L-Pop group [26].

The most micro leakage was observed in Prompt-L-Pop samples. Therefore, most of the examined dental bonding's were able to completely eliminate micro leakage in the occlusal walls, while some of these bonding's showed a statistically significant difference in the leakage in the gingival walls.

In 2003, Camps J and Pashley D demonstrated the validity of dye penetration studies. The purpose of this study was to compare the classic dye penetration method with the dye extraction method and the fluid-filtration method as a control. 40 teeth were divided into 4 groups of ten based on the sealer used in lateral condensation [27].

Apical flood of teeth was evaluated by three methods: Fluid-filtration, dye penetration with 2% methylene blue, and a new method called dye extraction with 65% nitric acid and absorption of methylene blue dye. Classical dye penetration showed no difference between sealers and was not related to the other two techniques. fluid-filtration and dye extraction showed that seal apex had the highest apical leakage. The relationship between the

results obtained with these two methods has been significant [28].

In 2004, Koliniotou KE et al demonstrated micro leakage of composites with new dentin adhesives in an in vitro evaluation. The aim of this study was to investigate the micro leakage of class V composite restorations with total etch and self-etch adhesives. 40 class V cavities were prepared on the buccal surfaces of canine teeth [29].

The holes were randomly divided into 5 groups of 8 and repaired with one of the investigated adhesive systems. After 60 days, the animals were killed and the teeth were extracted. Then the teeth were submerged in 0.5% fuchsia solution for 24 hours, cut and micro leakage was evaluated. The interface of tooth and restoration was also examined by SEM. The results showed that there is a significant difference between the groups. Total etch adhesives showed less micro leakage than self-etch adhesives. For all adhesive systems, the difference between occlusal and gingival micro leakage was significant, with the exception of Admira [30].

In a 2004 study, Brackett WW et al investigated the micro leakage of class V composite restorations with self-etch adhesives. The aim of this study was to compare the micro leakage of class V composite

restorations using a total etch adhesive (etch and primer separately). Class V composite resin restorations in cavities prepared on human third molar teeth, using two self-etch adhesives (Prompt-L-Pop with strong PH, One-Up Bond F with medium pH) and one total-etch adhesive (Scotch Bond Multi)-Purpose), done [31].

The restorations were thermocycled for 1000 cycles and subjected to dye penetration. Only leakage was observed throughout the gingival margins. The incidence of this leakage was 31% for Prompt-L-Pop and One-Up Bond adhesives and 50% for Scotch Bond Multi-Purpose adhesive.

In 2005, Gregoire C, Guignes Ph and their colleagues in a study showed the effect of self-etch adhesives on dentin permeability in fluid flow model. The aim of this study was to measure the hydraulic conductivity of physiological saline through dentin after the application of different self-etch bonding systems and a single-bottle adhesive system with phosphoric acid etching. 100 extracted humans third molar teeth without caries were used in this study. 100 dentin discs with a thickness of 1 mm were divided into 10 groups, each of which was repaired with one of 9 self-etch adhesives [32].



Figure 1. Cosmetic Dentistry Services

Total H Prime & Bond NT adhesive was also used as a control. Both sides of each sample were etched with 36% phosphoric acid for 30 seconds and hydraulic conductivity was measured every 30 seconds for 15 minutes. Measurements were repeated when creating the smear layer and after applying 10 adhesives. Total H control adhesive reduced dentine permeability by 42.3%. The highest rate of reduction in permeability was 68.9% with Xeno III self-etch adhesive. Permeability reduction was also different for other adhesives [33].

Brackett MG and colleagues in 2006 evaluated the micro leakage of class V composites using self-etch resins. The aim of this study was to compare the sealing of dentin and enamel margins using three types of self-etch bonding and an etch & rinse adhesive. Also, the improvement of the compatibility of enamel margins with the application of conventional etching of enamel before the application of self-etching adhesives was evaluated. On the extended third molars, class V cavities were carved and repaired with three self-etch adhesives (Adper Prompt L-Pop, i Bond GI and

Tyrian SPE) and one adhesive (Adper Scotch Bond Multi-Purpose) etch & rinse [34].

Also, in one group of teeth, enamel was etched in the usual way before the application of three self-etch adhesives. The restored teeth were thermocycled and subjected to dye penetration examination. In ivory margins, there was no significant difference between different adhesives in terms of leakage, but in enamel margins Adper Prompt and i Bond adhesives showed more leakage than etch & rinse adhesive.

The incidence of leakage of enamel margins was significantly reduced when enamel etch was applied before the application of both self-etch adhesives and total etch, but enamel etch before the application of three self-etch adhesives increased the leakage of dentine margins, but this increase was not significant [35].

In 2007, Deliperi S and colleagues, in a study, investigated the micro leakage of the repair interface using one total-etch adhesive and three self-etch adhesives. Thirty human premolars and molars without caries were extracted and used in this study. Standard Class V cavities were carved on the facial and lingual surfaces, such that the gingival margin was 1 mm below the CEJ. The teeth were randomly divided into 4 groups [36].

In group one, Xeno III one-step self-etch adhesive, in group two, Prime & Bond NT total etch adhesive, in group three, i Bond single-step self-etch adhesive, and in group four, Clear fil SE Bond, two-step self-etch adhesive. Then the teeth were restored by two pieces of Esthet-X composite with A2 color. The teeth were stored in distilled water for 90 days and thermocycled at 500 cycles. Then the samples were placed in 0.5% methylene blue solution for 24 hours at 37°C and after longitudinal cutting of the samples, the occlusal and gingival margins were evaluated to evaluate micro leakage with a stereomicroscope with X20 magnification [37].

Dye penetration was classified into Score 0 to 3 based on the depth of dye penetration. The results showed that the color penetration in group three was significantly higher than other groups, both in gingival and occlusal. When comparing the score of occlusal and gingival margins for each group, there was no significant difference in color penetration between Xeno III and Prime & Bond NT and i Bond margins. Clear fil SE Bond showed more color penetration in the gingival margin than in the occlusal margin.

In 2008, Claus_Peter Ernst and his colleagues, in a research, evaluated the edge uniformity of class five restorations by comparing the SEM method and the dye penetration method [38].

In this study, seven adhesives Opti bond FL, Scotch bond 1XT, Clear fil SE Bond, Adper Prompt, S3 Bond, I Bond and Hermes Bond were used along with Tetric Ceram composite and Hermes Siloran base composite. Class V standard cavities were

shaved in 70 human teeth and adhesives were used for restoration according to the instructions of the manufacturer and the cavities were repaired with three composite pieces. After finishing, polishing and thermocycling, the samples were evaluated in terms of margins by SEM and dye penetration (S10 in methylene blue and '30 in methylene blue) [39].

The results showed that the SEM data has no relationship with the 10-second dye penetration data. There was correlation between SEM data and dye penetration data, 30 minutes in enamel margins. No correlation was found between the data of three methods (SEM, dye penetration for 10 seconds and dye penetration for 30 minutes) in cementum margins (lacking enamel). Because 30-minute dye penetration had a better relationship with SEM than 10-second dye penetration, therefore, 30-minute dye penetration time is better than 10-second time to evaluate leakage.

Hashem AA and Hassanien EE in 2008 used the dye extraction method in a study to evaluate the perforation flood of Forkishin with different materials. In this article, they described the dye extraction method as follows. After immersing the samples in methylene blue, they were placed in vials containing 65% by weight of nitric acid and centrifuged at 14,000 revolutions, and the absorption of dye at a wavelength of 550 nm was evaluated using a spectrophotometer [40].

Today, the use of tooth-colored materials to repair lesions and caries has become very popular. One of the main reasons for this trend is the beauty of this type of restorative material. Composite resins are considered among aesthetic restorative materials and are commonly used to repair class five carries and lesions, together with self-etch or total-etch dentin adhesives.

In Gregoire's study in 2005, contrary to our study, using the fluid filtration method, Xeno III self-etch adhesive has less leakage than Prime & Bond NT total etch adhesive. The reason for this difference in the leakage of adhesives in our study with Gregoire's study may be the difference in the type of self-etch and total-etch adhesives investigated. As mentioned earlier, in this research, three micro leakage evaluation methods were used, namely fluid filtration, dye penetration and dye extraction. In Pashley's study in 2003, three methods, fluid filtration, dye penetration, and dye extraction, similar to our research, were used to evaluate apical leakage and determine the statistical relationship of micro leakage evaluation methods [41].

While in most of the previous studies such as Manhart in 2001(65), Yazici in 2002(66), Koliniotou in 2004 and Brackett in 2004 and 2006(68 and 70), only the Dye Penetration method was used to evaluate micro leakage of composite restorations. In his study in 2005, Gregoire used only the fluid filtration method to evaluate ivory flooding

and Hassanien in 2008 used a newer method called dye extraction to evaluate furcation flooding [42]. In this method, the absorption of methylene blue dye at a wavelength of 550 nm is measured by a spectrophotometer and thus micro leakage is determined. In this study, in order to investigate the relationship between three types of micro leakage evaluation methods, Fluid filtration method is considered as control and the statistical relationship of two other methods with this method is measured, which is similar to Camps and Pashley's research in 2003. They also used the fluid filtration method as a control in their study and measured the relationship between the two-dye penetration and dye extraction methods [43]. The results of their study showed that in the evaluation of the apical seal of several types of adhesive sealer, the dye penetration method has no significant relationship with the two methods of fluid filtration and dye extraction. Because the data of the dye penetration method is qualitative unlike the other two methods.

In our study, Pearson's correlation coefficient was used for the quantitative data of Fluid filtration and dye extraction and spearman's correlation coefficient was used for the qualitative data of dye penetration to investigate the statistical relationship between micro leakage measurement methods.

The results showed that there is no significant relationship between dye extraction and fluid filtration methods in the evaluation of leakage in both types of total etch and self-etch adhesives studied using Pearson's coefficient, and using Spearman's coefficient, there is no statistical correlation between dye penetration methods and fluid filtration was not obtained in these two types of adhesives [44].

Conclusion

Previously, in the studies of Pashley 2003 and Hassanien 2008, dye extraction method was used to evaluate the apical flood, but until now, no study has been done on this method to evaluate the coronal flood of restorations, and in our research, we used this method to evaluate the micro leakage of composite restorations. More recently, we also used dye extraction. In dye penetration method, the micro leakage of total etch adhesive (1.5 ± 1.24) was more than self-etch adhesive (1.3 ± 1.3), but using the Wilcoxon test for the qualitative data of this method the difference in micro leakage of these two types of adhesives was not significant ($P=0.755$).

In Brackett's study in 2004, similar to our study, with the qualitative dye penetration method, total etch adhesive Scotch Bond Multi-Purpose (with an incidence of 50%) was more than self-etch adhesive Prompt L-Pop and One- UP Bond (with an incidence of 31%), but this difference is not significant in micro leakage.

In Brackett's study in 2006, similar to our study with the dye penetration method, in terms of micro

leakage, there was no statistically significant difference between Prompt L-Pop, i Bond, and Tyrian self-etch adhesives and Scotch Bond Multi-Purpose Total Etch adhesives in terms of micro leakage. In the fluid filtration method, in our research, the micro leakage of adhesive self-etch (0.00035 ± 0.000021) was more than that of total adhesive (0.000011 ± 0.000012) and the paired t test also showed that the micro leakage difference of these two types Adhesive has been significant ($P=0.002$). Similar to our study in Koliniatou's research in 2004, self-etch adhesive has significantly more micro leakage than total-etch adhesive, but in Koliniatou's study, only dye penetration method was used, not fluid filtration method.

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Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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