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Dental Composite Curing System Apparatus and Method

Dr. Mohammad Al Rifai

Shrinkage and stress is a common issue in the field of composite restorations. Dentists face this issue daily across the world, and no effective solution to address this problem has been reached yet. The idea behind this invention was to solve this problem and to minimize the unfavorable shrinkage and stress in the composite restorations. My research was done as a development and a contribution to the continuous efforts to solve this issue and improve dental outcomes.

Inventor: Dr Mohammad Al Rifai

This invention will be a revolution in the field of dental composite restorations as it will change the prevailed principles and modify the current rules of composite application significantly. With the techniques used in this research, any composite material that has inferior properties concerning stress or shrinkage will behave as an ideal composite restorative material. These results were achieved through decreasing the shrinkage, and stress up to 70% for the same materials currently used by dentists. This motivated me to publish my invention.

The idea was to reduce the negative effects of stress and shrinkage of composite polymerization. The research and development departments in manufactories and universities tried to get the minimal negative effects of composite shrinkage throughout many ways like:

1. As resin is the main reason for shrinkage in composite they tried improving the quality of the resin matrix and tried to reduce its quantity in the composite mix.

2. Development of the curing light device (light source) by increasing the power of the light up to 1,600 mw/cm ^{2}, and increasing the range of the light wave length from 300 to 500 nm, or using soft start technique and changing the direction of the light beams from straight to angled beam (conic shape)

3. In addition to the above, other techniques were used but with a minimal impact in reducing the negative effects of the composite shrinkage, such as using perforated plates with different shapes but unfortunately these techniques were not successful and failed.

Based on all of the above, we will explain the difference between this invention and other procedures.

Here are some introductory explanations:

1. The light beams in all light cure devices are divergent and have a conic form

2. During composite polymerization, unfavorable shrinkage and stress appears

3. Stress is the force produced from the shrinkage of the restoration connected to the edges of tooth's walls at the same time the adhesion to the walls is greater than the shrinkage force (adverse effect). The stress power always concentrates at the corners of any shape like a triangle or rectangle unlike the circular shape.

4. Using the perforated plate is to divide the curing process in the restoration to cured and uncured areas, so the uncured areas will slightly expand and compensate the shrinkage generated by cured areas, and the benefits from this division is that the stress and shrinkage are allocated to many areas in the restoration and are not concentrated in the edges of the restoration. When the restoration gets cured without perforated plate, shrinkage and stress will pull the restoration to the center and the tooth's walls will prevent this action. (fig 1.1 -1.2)

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The first experiment with the perforated plate was not successful and we tried to find the reasons for the failure. The problem using the perforated plate is that large parts of the restoration cured or the whole restoration cured (Keeping in mind that the transformation from the plastic state to hardness takes 3 to 5 seconds). The reasons for failure were:

Lack of closed space between the holes of the perforated plate to prevent the light beam from reaching the restoration so there were not enough uncured masses between the cured areas. And since the light beams diverge from the source this will increase the cured area and might cure the whole restoration. (fig 2)

To solve this issue I came up with the idea of leaving 1mm of closed space between the holes, and the diameter of the holes is also 1mm. Why 1mm and not more or less?

The main concept is trying to find the best com - bination that allows the highest number possible of perforations and achieve the highest number of both cured and non cured areas in the com - posite restoration (i.e. the smallest size of perfo - rations and the smallest distance between the perforations)
I tried several combinations of both perforation size and separating distance, and found the fol - lowing :

I. Perforations of 0.5 mm in diameter, did not allow sufficient amount of curing light to pass through the perforated plate and thus was not able to induce the desired curing effect in the composite.

II. Perforations of 1 mmin diameter, allowed enough amount of curing light to pass through the perforated plate (I recorded 400 m watt/ cm^2 out of a source of 1100 m watt/ cm^2) and was able to induce the desired curing process in the composite.

III. Perforations of more than 1 mm were not desirable, mainly for two reasons:

1- This will reduce the number of perforations pos - sible which contradicts with the general concept.

Fig 1.1

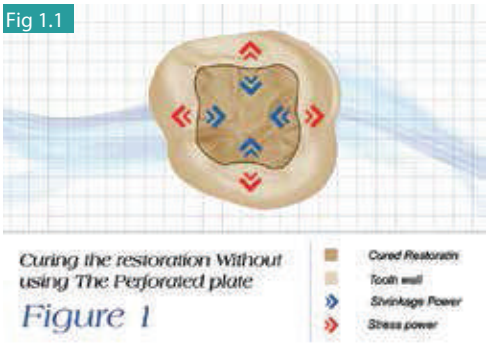


Fig 1.2

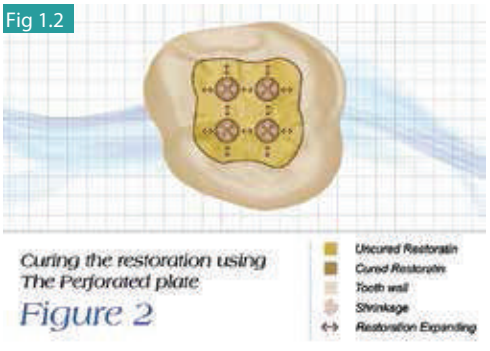
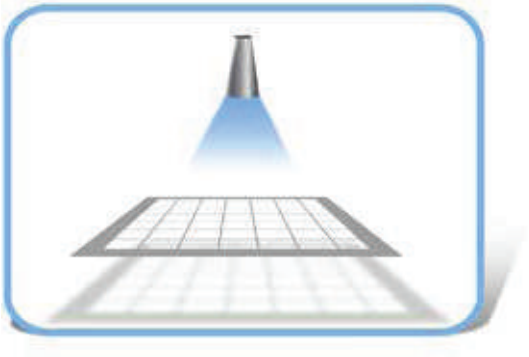


Fig 2



2- In dental practice there are restorations of 1.5- 2 mm in size. Which means that a perforation of 1.5 mm or 2 mm in diameter has the potential of covering the total surface of the restoration and cause the curing in the whole restoration which is what we are essentially trying to avoid.

IV. Perforations of 1 mm diameter and the holes 0.5 mm apart. I found that the light beams pass - ing through the perforated plate (the plate must not exceed 0.5 mm in thickness to reduce the attenuation of the curing light power) have al - most reunited on the restoration surface after passing through the plate (due to the divergent

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pattern of the light beams passing through the plate) and caused the curing effect on almost the whole restoration mass.

V. Perforations of 1 mm diameter and holes 1 mm apart. This combination allowed for enough light power to pass through with suitable separations, and achieved the desired result of both cured and non cured areas of the composite restoration.

VI. Perforations of 1 mm and 1.5 - 2 mm apart were not suitable for reasons very similar to the reasons that lead to the rejection of 1.5-2 mm perforations above.

In conclusion I have found a plate of 1 mm in diameter perforations and holes 1 mm apart to be the best combination that allows for enough curing light power to pass through the perforated plate, and achieve the desired curing process.

And why circular holes?

My experiments indicate that this form will result in minimal shrinkage effects in comparison to other suggested geometrical forms. Furthermore, circular holes do not contain any angles (in contrast to the other suggested shapes of parallel lines or grid). And since it's well known in the field that stress points are usually formed in the corners. This will result in minimal stress points formation in the restoration after polymerization.
Based on the above and after the experiments, I should get a cylinder or cone shaped curing in the restoration using a perforated plate with circular holes, but I got different result, I got random shapes with a bigger volume than expected and it was big enough to fuse with the next cured blocks. The reason for getting random and bigger shapes is the vibration in the doctor's hand during the curing process, and due to this vibration there is a change in the light beam direction coming from the light source into the holes and this will cure areas in the restoration under the covered areas between the circular holes and curing this unwanted areas caused a bigger and random masses of cured composite.

To solve this issue and mitigate the vibration in doctor's hand I found that we should fix the light source with the perforated plate and the tooth all together, and for this I designed a special handle to solve the vibration in the doctor's hand and this handle has other advantages also (fig 3, 4.1, 4.2)

Fig 3

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Fig 4: A simple illustration of the handle

1. Flexible metal ring.
2. Fiber glass tube end of the light curing device.
3. Metal holder joining with the ring and the plate.
4. Perforated plate.
5. Leg of the holder de - signed to stand on the side of the tooth.
6. The passing light beam through the plate.

Fig 4.1

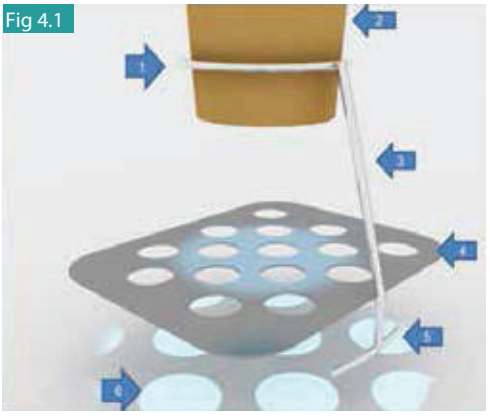
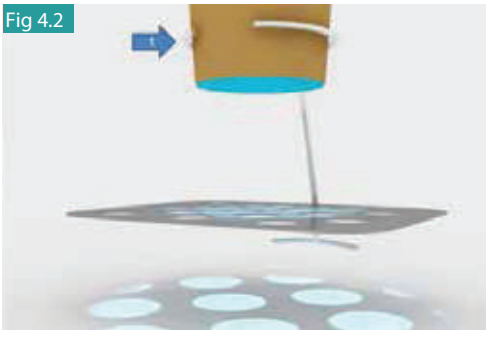


Fig 4.2



In this new design, the plate was carried inde - pendently to fix it on the tooth and put the light source over it.
In this pattern, the plate can be fixed under the light curing device directly by the flexible metal ring (1), then the device and the plate can be fixed on the tooth. This provides ease in treat - ment, and good stability of the plate over the tooth. So, the light beam doesn't suffer from shaking during the curing process.
The plate can be fixed by a flexible ring that al - lows the head of the fiber glass tube to be in - serted into the ring (1), and the ring is not closed. It allows a simple expansion in dimensions. This makes the ring suitable with a large number of devices as in figure 4.
The ring allows moving the plate and the holder in different directions around the axis of the tube of the curing device, where the leg of the holder (5) can stand on different walls of the tooth (lingual, Buccal).
After using the handle with the perforated plate, we got acceptable results where the dimensions and the shapes of cured restoration had conical shapes, and didn't fuse with each other.

Some details of the suggested design:

1. 0.5 mm thickness of the perforated plate is optimal, because if the plate was thicker, (1 mm thickness) will reduce the light beams passing through the holes and this will reduce the cured area significantly.
And if the plate is thinner than 0.5 mm, this will allow larger light beams to pass through holes and will increase the cured areas significantly.
2. The design of the handle is allowing the plate to rotate 360 degrees around the tube of the light cure device, which will give the doctor the ability to use the plate over any surface of the tooth, upper, lower, right or left tooth.
3. The design allows minimal distance between the light source, plate and tooth surface.
4. It is easy to produce the device commercially with low cost and with the ability to get steril - ized (since it is made of stainless steel)
5. The shape of the part of the handle to be fixed on the tooth surface is curved allowing high stability on the tooth surface.

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