*Review Article*

Indian Journal of Dental Education
Volume 13 Number 4, October–December 2020
DOI: https://dx.doi.org/10.21088/ijde.0974.6099.13420.3

# C-Factor in Root Canal

**Sameer Makkar[1], Divyangana Thakur[2]**

**Author's Affiliation:** [1]Professor, Department of Conservative and Endodontics, Bhojia Dental College and Hospital (Dentist), Baddi, Himachal Pradesh 173205, India. [2]Student, Department of Conservative and Endodontics, Swami Devi Dyal Hospital and Dental College, Panchkula, Haryana 134118, India.

**Corresponding Author: Divyangana Thakur,** Student, Department of Conservative and Endodontics, Swami Devi Dyal Hospital and Dental College, Panchkula, Haryana 134118, India.

**E-mail:** divyangana.thakur@gmail.com

**How to cite this article:**
Sameer Makkar, Divyangana Thakur, C-Factor in Root Canal. Indian J Dent Educ. 2020;13(4): 161–165.

**Abstract**

C-factor is an important clinical consideration regarding its effect on polymerization shrinkage. Throughout the entire polymerization process, plastic deformation or flow of composite occurs along the unbounded surface that might partially relieve the induced shrinkage stress. Such compensation through flow is affected by C-factor of the restoration. This review article tries to throw some light over this topic.

**Keywords:** C-Factor; Polymerization shrinkage.

## Introduction

Interest in the application of adhesive dentistry concepts to endodontics to create improved apical and coronal seal that have been stimulated by the introduction of methacrylate resin-based sealers and dentin adhesives for endodontic use.

Shrinkage stresses associated with polymerization of methacrylate-based resins are higher in low-filled, lower viscosity resin cements, and root canal sealers than highly filled resin composites. A major problem associated with endodontic bonding is the lack of relief of shrinkage stresses created in deep, narrow canals. Stress relief by resin flow is dependent upon cavity geometry and resin film thickness.[1-4]

During polymerization, the unbonded surface can move and flow, thereby relieving shrinkage stresses. However, as the unbonded surface area becomes small, as in a long narrow root canal, there is insufficient stress relief by flow and a high probability than one or more bonded areas will pull off or debond. During the era when bonding to root canals was in its infancy, Feilzer et al opined that bonding to post spaces represents the worst scenario in achieving leak-free interfaces.[1-3]

Polymerization shrinkage and subsequent stress of resin material was considered to be a principal reason for the failure of restorations. The magnitude of shrinkage value was found to be mainly dependent upon the resin volume, so called ''volumetric shrinkage. When polymerization shrinkage takes place under confinement, as in the case of bonding to a cavity wall, contraction stress will develop within the material. The quantitative value of the confinement of the cavity could be represented by the C-factor value, which is defined as the ratio between bonded and unbonded surfaces of the resin.

During polymerization, the unbonded surface can move and flow, thereby relieving shrinkage stresses. However, as the unbonded surface area becomes small, as in a long narrow root canal, there is insufficient stress relief by flow and a high probability than one or more bonded areas will pull off or debond.

The vulnerability to debonding may be predicted by assessing the geometric attributes of a cavity, the generation of actual shrinkage stresses and how these stresses are ultimately dissipated must rely on other critical parameters such as the

-amount of volumetric shrinkage of the resin sealer,

- elastic moduli of the intraradicular dentin,
- adhesive sealer,
- root filling material,
- contribution of air voids within the sealer in stress relief
- the rate of polymerization
- gelation time of the resin sealer,

In view of the high probability for imperfect dentin bonding (i.e. debonding because of polymerization contraction forces exceeding bond strengths) in root canals and the high volumetric shrinkage that is anticipated with low viscosity resinous materials, a slow polymerizing resin sealer would improve the chance for the relief of shrinkage stress via resin flow, because of prolonged gelation time. Indeed, the manufacturer of the Resilon sealer has taken this issue into consideration by creating a sealer that auto-polymerizes in 45 min at room temperature.

However, the manufacturer's instructions to create an immediate coronal seal via light-curing of the resin sealer would cancel out the benefits derived from a sealer that is designed for very slow auto-curing dynamics.

According to Tay et al 2005 the thicker sealers can partially compensate for high theoretical C-factors by increasing the unbonded surface area and permitting some stress release by resin flow. At clinically relevant sealer thickness the percentage increase in C factor overwhelms the percentage decrease in stress factor (volume of shrinkage is reduced, volumetric shrinkage is reduced). Thicker sealers can partially compensate for high theoretical C-factors by increasing the unbonded surface area and permitting some stress release by resin flow. For instance, at a sealer thickness of 2µm in a 20-mm long root canal, the theoretical C-factor of 954 could be reduced some because of the linear decrease in S-factor. Despite the potential reduction in C-factors with a low sealer thickness, it could be seen from the sealer thickness that indirect bonding in long narrow root canals still resulted in exceedingly high C-factors when compared to indirect intracoronal restorations with similar resin film thickness.

The increases in C-factors associated with increasing file size are modest when compared with the changes that are associated with reducing the sealer widths. C-factors decrease with increasing file size when a root canal is filled with an adhesive sealer without the use of a bondable root filling material.

C - Factor for root canal was 46 for sealer thickness of 500 µm

C- Factor for root canal was 23,461 for sealer thickness of 1 µm

C- Factor for root canal was 32 for canal with only sealer.[6]

As resin tags also adapt to the inner wall of tubules and create bonded areas peripherally when a dentin adhesive is allowed to autocure before the application of a resin sealer, the availability of dentinal tubules for stress relief is conjectural.

Whereas vulnerability to debonding may be predicted by assessing the geometric attributes of a cavity, the generation of actual shrinkage stresses and how these stresses are ultimately dissipated must rely on other critical parameters such as the amount of volumetric shrinkage of the resin sealer, the elastic modulus of the intraradicular dentin, adhesive, sealer, and root filling material, the contribution of air voids within the sealer in stress relief, the rate of polymerization and gelation time of the resin sealer , and the expansion/contraction involved during thermal plasticization of the root filling material.[7-9]

***Post-Space***

The cavity configuration factor (C-factor), which represents the confinement area of the cavity, increases enormously after a fibre post is inserted. The bonded surfaces include both the root canal dentine and the fibre post surface. It has been reported that the C-factor in endodontic post-luted cavities may exceed 200, whereas the C-factor of an intracoronal restoration is in the range of only 1–5. The restriction of free surfaces in such a deep and narrow canal would have a detrimental effect on the adhesion of the fibre post to root canal dentin. The difference in the bonding performance of the adhesives in intra-coronal cavities and those in post-spaces may be accounted for by the difference of the configuration factor (C-factor).

The unstable bonding performance of adhesive materials in the post-space may be attributed to the high C-factor.

The C-factor typically varies from 1 to 5 in intracoronal restorations, it is estimated to exceed 200 in a postspace.

The slower setting materials reduce stress at the bonding interface by allowing the flow of the materials to relieve polymerization stress.[5]

The complex configuration of the adhesive interfaces is another factor which compromises stable adhesion in the post restoration.

An adhesion with an fibre post comprises three layers with two bonding interfaces, which are dentin/adhesives and adhesives/post interfaces. The bond strengths of modern dentin adhesive systems to root canal dentin in a post-space were more than 50 MPa, while those to a fiber post treated with a silane coupling agent were 20— 30 MPa.

Such unevenness of the bonding strengths at the two interfaces can result in contraction gaps at the interfaces, with inferior bonding strength.

However, the stress accumulation due to polymerization shrinkage at the weaker interface is not easy to predict because of the complicated configurations of the post—core adhesion involving two interfaces with three layers surrounding the post.

Using adhesive materials which have similar bond strength to the root canal dentin and to the FRP may offer a possible solution to reduce the contraction gaps.[12]

### *Limitation of Light Penetration into Postspaces*

An incompatibility between the uncured acidic monomer and the chemically activated resin at the apical portion might occur 32, resulting in inferior bond strength values. In contrast, there were no regional differences in bond strength values of fibre post-inserted canals. Light passing through a translucent post might be able to activate the thin resin layer surrounding the post surface, enabling the resin to cure promptly along the post

Several studies on the bonding performance of fibre post and root canal dentin using light-cured and dual-cured adhesives reported that bond strengths were affected by the vertical location in the post-space

Stresses produced by polymerization shrinkage also complicate the firmness of bonding when luting the fibre to its post-space with adhesive materials.

The inferior performances of the bonding in apical areas when using light-cured adhesives demonstrated that achieving high bond strength throughout an entire root canal is difficult.

Imperfect curing of the adhesives at the apical portions may be the cause of the inferior bond strengths.

The difficulties in getting the light fully to penetrate the deepest apical portions were proved by evaluating the depth of light-initiated polymerization of glass fiber reinforced composite materials into the root canals.

The limitation in the distance of light penetration resulted in a low degree of conversion of polymerizable dimethacrylate resin monomers.

When the distance from the light source to the irradiation surface was increased, the degree of conversion of resin monomers decreased.

The hardness of the composites also fell by 25% when the distance from the irradiation surface to the irradiation unit was increased from 4 to 8 mm.

To overcome this disadvantage of insufficient light penetration in a narrow post-space, prolonging the photo-irradiation time for light-cured dentin bonding systems was found to be effective to improve the bonding strength to root canal dentin.

Other options, such as using a LED fiber or a transparent light-guiding attachment, which can be inserted into the deepest parts of the apical portions, could be considered in clinical use.

Using chemically cured adhesive materials, where the progress of curing is relatively slow and the slower process of polymerization shrinkage produces less stress, may have an advantage in root canal adhesion, where extremely high stress is generated in the post-space.

Chemical curing is also advantageous in promoting even distribution of the stress caused by the polymerization shrinkage and inducing even bonding strength in the entire post-space.

However, the reported bond strengths of chemically cured adhesives with the fibre to the root canal dentin do not seem to be superior to those with light-cured materials. This may be because the basic bonding strength of chemically cured adhesives is not strong enough to cope with the high stress generated in the post-space. Dual-cured adhesive materials have been recommended for use in bonding in root canals, in the expectation that they will show the advantageous characteristics of the light-cured materials at the cervical area of a post-space and those of chemically cured materials at the apical area. However, actual bonding performances in a post-space seem not to be improved when compared to those with light-cured adhesives. Inferior adhesions at the apical area were still observed even when using dual-cured adhesives. As mentioned above, this may be because the bonding of chemically cured ingredients is not strong enough to counteract the high stress at the apical area.

Another problematic consideration is the thick smear layer during the post preparation. Goracci et al. reported that a total-etch resin cement showed greater bonding potential than a self-etch or a self-adhesive resin cement when luting the FRP to radicular dentin. It may be because acidic monomers responsible for substrate conditioning in the self-etch and self-adhesive resin cement were less effective in etching through the thick smear layer. This might have accounted for the significantly lower retentive strength of the FRP to the radicular dentin. Clinicians should control the thick smear layer using etching agent such as EDTA with appropriate duration time and concentration.

### *Surface treatment of fiber posts*

Various approaches from both mechanical and chemical viewpoints have been made to improve the bonding between FRP and resinous adhesive materials. Several studies have reported that a silane coupling agent has positive effects in enhancing the bond strength of resin composite to FRP. Aksornmuang et al. showed that such enhancing effects were much clearer in quartz fiber posts than in silica— zirconium glass fiber posts. Monticelli et al reported that a combination of a silane coupling agent with two-step self-etch adhesives were highly efficient. However, Perdigao et al claimed that the silane coupling agent did not increase the bond strength of dentin adhesives to the FRP. This inconsistency in the findings of the reports may be explained by the differences in the composition of the post and the luting materials used, the mode of the testing, and the configurations of the post-spaces. Sandblasting has been suggested as an effective mechanical approach to enhance the bond strength of dentin adhesives to fibre post. However, we need to consider whether the mechanical properties of fibre post are compromised by the sandblasting. Fibre post has exhibited a significant decrease in mechanical strength after thermal cycling. This has been attributed to degradation of the fibers or the matrix and to the difference in thermal expansion coefficients between the two Another study examined the clinically feasible protocol for creating micromechanical retention on the surface of the FRP, using $H_2O_2$ etching to remove the surface layer of epoxy resin. Interfacial retention strengths were enhanced through the use of a combination of $H_2O_2$ etching and silanization. After this treatment, flowable composites can completely infiltrate the interdiffusion zone.

Thicker sealers can partially compensate for high theoretical C-factors by increasing the unbonded surface area and permitting some stress release by resin flow

In view of the high probability for imperfect dentin bonding (i.e. debonding because of polymerization contraction forces exceeding bond strengths) in root canals and the high volumetric shrinkage that is anticipated with low viscosity resinous materials, a slow polymerizing resin sealer would improve the chance for the relief of shrinkage stress via resin flow, because of prolonged gelation time. Indeed, the manufacturer of the Resilon sealer has taken this issue into consideration by creating a sealer that auto-polymerizes in 45 min at room temperature.[15-17]

For warm vertical compaction techniques, the rate of chemical polymerization of the sealer may also be accelerated by heat application of up to 150°C.

## Conclusion

C-factor plays an important role in cavity and now also in root canal due to introduction of resin sealers in market. This ireview tried to throw some light on how C factor affects the shrinkage in canal also. So the better understanding is required for C factor, for this more studies are required to be done in root canals.

## Refrences


1. Dr. András Fulmer, University of Pécs; Semmelweis University; Dialog Campus Publishing House - Nordex Ltd.
2. Juthatip Aksornmuang. Effects of C-factor and resin volume on the bonding to root canal with and without fibre post insertion.2011
3. Alomari QD, Barrieshi-Nusair K, and Ali M. Effect of C-factor and LED Curing Mode on Microleakage of Class V Resin Composite Restorations. 2011 Oct; 5(4): 400–408.
4. Ferracane JL. Developing a more complete understanding of stresses produced in dental composites during polymerization. Dent Mater. 2005;21:36–42.
5. Hyashi M.Key factors in achieving firm adhesion in post and core.Japanese Dental

Science Review.2008.44,22-28.

6. Franklin R Tay , Robert J Loushine, Paul Lambrechts, R Norman Weller, David H Pashley. Geometric factors affecting dentin bonding in root canals: a theoretical modeling approach. J Endod 2005 Aug;31(8):584-9.
7. Leonard DL, Charlton DG, Roberts HW, Cohen ME. Polymerization efficiency of LED curing lights. J Esthet Restor Dent. 2002;14:286–295.
8. Fróes-Salgado NR, Pfeifer CS, Francci CE, Kawano Y. Influence of photoactivation protocol and light guide distance on conversion and microleakage of composite restorations. Oper Dent. 2009;34:408–414.
9. Cunha LG, Alonso RC, Neves AC, de Goes MF, Ferracane JL, Sinhoreti MA. Degree of conversion and contraction stress development of a resin composite irradiated using halogen and LED at two C-factor levels. Oper Dent. 2009;34:24–31.
10. Swift EJ., Jr Dentin/enamel adhesives: review of the literature. Pediatr Dent. 2002;24:456–461.
11. Nalçaci A, Salbaş M, Ulusoy N. The effects of soft-start vs continuous-light polymerization on microleakage in class II resin composite restorations. J Adhes Dent. 2005;7:309–314.
12. Soh MS, Yap AU, Siow KS. Post-gel shrinkage with different modes of LED and halogen light curing units. Oper Dent. 2004;29:317–324.
13. Tay FR , Loushine RJ, Lambrechts P, Weller RN, Pashley DH.Geometric factors affecting dentin bonding in root canals: a theoretical modeling approach. J Endod. 2005 Aug;31(8):584-9.
14. Trope M. Resilon will biodegrade from lipases released by bacteria or by bacterial or salivary enzymes. J Endod. 2006 Feb;32(2):85.
15. Priscilla Cristoforides Pereira; Renata MZarques de Melo; Carolina Chave, Graziela A. P. Galhano; Marco Antonio BottinoIV; Ivan Balducc. The adhesive system and root canal region do not influence the degree of conversion of dual resin cement. J. Appl. Oral Sci. vol.18 no.5 Bauru Sept./Oct. 2010.
16. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, Mjor IA. Bonding to root canal: structural characteristics of the substrate. Am J Dent. 2000;13:255-60.
17. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, Mjor IA. Bonding to root canal: structural characteristics of the substrate. Am J Dent. 2000;13:255-60.