Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.14.013

Apical Extrusion of Debris During Instrumentation Using Two Different Rotary Files System in Permanent Teeth- an in Vitro Study

Aravindhan.K[1], Delphine Priscilla Antony S[2*]

[1]Postgraduate student, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Indi

[2]Reader, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India

***Corresponding author:** Delphine Priscilla Antony S, Reader, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India

Submitted: 02 March 2023; Accepted: 25 April 2023; Published: 13 May 2023

ABSTRACT

Aim: The aim of this study was to compare the amount of apically extruded debris during preparation with ProFit S3 files and ProTaper NEXT (Dentsply Mailefer).

Materials And Methods: Thirty extracted single-rooted premolars which were recently extracted and preserved in physiological saline solution were used. All the samples were standardized to 16 mm. Standard endodontic access was prepared using endo access bur (Dentsply Maillefer, Switzerland). The initial patency was established using #10 k file (Mani, Utsunomiya, Tochigi, Japan) to the working length.. Two different rotary files systems were used for cleaning and shaping. Debris was collected in the Eppendorf tube and then weighed using microbalance.

Results: It shows that significant differences between ProFit S3 and ProTaper NEXT showed increased debris extrusion.

Conclusion: It can be concluded that all the file system extruded debris beyond apical foramen.The ProFit S3 group showed lesser debris extrusion when compared to ProTaper NEXT.

Keywords: *permanent, system, dentistry, technical, teeth, study*

INTRODUCTION

The primary goal of endodontic treatment is to obtain adequate disinfection of the root canal space in order to prevent recurrence of apical periodontitis(1)(2). Nickel Titanium instruments are used to clean and shape the root canals productively compared to manual instrumentation(3,4).The goal of canal instrumentation is to create a continually tapering conical preparation that replicates the anatomy of the canal while maintaining the foramen as clean and free from any deviation from the original anatomy and curvature of the canal. In order to achieve the highest level of cleanliness and disinfection inside the root canal system, the process includes not only canal shaping but also the use of intracanal irrigants(5)(6)(6,7) Establishing the working length of the canal is an important step in this process. The distance between a stable coronal reference point and the location where root canal preparation

and obturation must end is known as the "working length," according to the endodontic lexicon.Ingle (1973) stated that the WL must be 0.5mm short of the external root surface; Weine (1982) stated that it must be 1 mm short of the radiographic apex.

Injuries caused by mechanical or chemical agents are frequently attributed to iatrogenic causes. Instrumentation (mostly overinstrumentation) and overextended filling materials are two examples of mechanical irritation that results in periradicular inflammation. Irrigants, intracanal medications, and overextended filling materials are some examples of chemical irritants.The development of discomfort, swelling, or both within a few hours or days following root canal procedures is known as the "interappointment flare-up,".Studies have documented different frequencies of flare-ups, ranging from 1.4% to 16%(8)(9)(10)

One of the main causes of postoperative discomfort is the extrusion of contaminated debris to the periradicular tissues during chemomechanical preparation(11)(12).There is a balance between the host defenses at the periradicular tissues and the microbial aggression from the infecting endodontic microbiota in silent chronic Periradicular lesions associated with infected teeth. If microorganisms are extruded into the periradicular tissues during chemomechanical preparation, the host will be confronted with a scenario in which it will be more challenged by irritants than it was previously(13)(14).

ProFit S3(PS3)(Kedo Dental, India) is a new heat-treated file system with blue technology that is coated with titanium oxide coating. It has a rectangular cross-section with a two-point contact which reduces debris extrusion apically. Its taper is variably variable (VV) between 4% to 8% with increased flexibility, adequate shape memory and more resistance to fracture(3)

The ProTaper Next (PTN) rotary system (Dentsply Tulsa Dental, Tulsa, OK) is composed of a set of instruments that are designed with variable tapers and an off centered rectangular cross-section, which generates a swaggering effect along its active portion(15). By minimizing contact between the file and the dentin, an off-centered rectangular shape reduces the screw effect, perilous taper lock, and torque on any particular file(15,16).

The purpose of this study was to investigate the quantity of apical debris produced in vitro using two different nickel-titanium rotary file instruments.The null hypothesis was that there was no difference in the apical debris extrusion, between the tested NiTi rotary instruments in single-rooted teeth.

MATERIALS AND METHODS

Tooth Selection and Preparation of specimen

Thirty extracted human mandibular premolar teeth with fully formed apices were included in this study. The teeth exhibited no defects, root canals were not calcified, showed no internal or external root resorption, no signs of prior endodontic treatment, and no aberrant canal morphology; each tooth had a single canal and a single apical foramen, based on buccal and proximal radiographic examination. Crowns were decoronated to increase standardization, and only teeth measuring 16 mm were included in the analysis(17). Schneider's methods were used to select mandibular premolars with fully formed apices and curvature angles of 0°–10°(18). The teeth in this study were extracted for periodontal or orthodontic purposes and preserved in normal saline at 4°C until they were required(19)(20). By using a diamond disc to decorate all of the samples, they were all uniform to 16 mm in length.(17,19). The access cavity was prepared using Endo Access bur, 21 mm size 2 (Dentsply Maillefer, Swiss made) was used and K-file (Mani, Utsunomiya, Tochigi, Japan) of size #10 hand files were used to achieve the initial patency of the canal to full working length (WL), visible at the apical foramen, and the WL was established 1 mm short of this length.(21)

The experimental model described by Myers and Montgomery in 1991(22) was used in this study. In order to weigh the tooth, a hole was drilled in the Eppendorf tube's stopper, and the tooth was then placed so that the cementoenamel junction remained 1-2 mm above the stopper. As a drainage cannula and to equalize the air pressure within and outside the tube, a 27-G needle was positioned next to the stopper.The Eppendorf tubes were then inserted into vials coated in aluminum foil, so that the operator wouldn't be able to see the root apex when instrumenting. Each stopper had a tooth and a needle attached to it.

Pre Weighing of the Eppendorf Tubes

Stoppers were separated from the Eppendorf tubes. A microbalance was used to measure the weights of the tubes. Three consecutive weights were obtained for each tube, and the average was calculated.

Root Canal Instrumentation with the PTN

The files were employed in an electric motor (X-Smart, Dentsply Tulsa Dental) that ran at 300 rpm and 300 gcm torque. Until resistance was felt in the canal, the X1 file (17/.04, Dentsply Tulsa Dental) was utilised in a brushing outstroke motion. The document was then removed, cleaned, and examined before being used again. After using distilled water to rinse the canal, a #10 K-file from Dentsply Tulsa Dental was used to check for patency. These steps were repeated until the WL received the X1 file.. The same procedures were performed with the X2 file (25/.06, Dentsply Tulsa Dental). A total amount of 5 ml distilled water was used.

Root Canal Instrumentation with the ProFit S3 Files

Until the WL was reached, the ProFit S3 files (PF1 AND PF2) were employed in an electric motor (e3, Dentsply Tulsa Dental). The file was removed after three pecking motions, cleaned, and examined before being reused. After using distilled water to rinse the canal, a #10 K-file from Dentsply Tulsa Dental was utilised to check for patency before being reused. The file was processed in this manner repeatedly until it reached the WL.

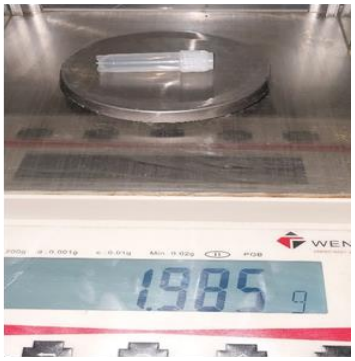
Post Weighing of the Eppendorf Tubes:

When the instrumentation was complete, the Eppendorf tube's stopper, needle, and teeth were removed. The tubes were stored in an incubator at 55°C for 5 days to let the distilled water evaporate before being weighed with the dry debris. They were weighed and calculations done. The Eppendorf tubes containing the extruded debris were weighed using the same analytical balance to determine their final weight. Three weight readings in a row were collected for each tube. The dry weight of the extruded debris was estimated by subtracting the weight of the empty tube from the weight of the tube containing the debris.

Data Analysis

Statistical analysis was performed using SPSS version 22.0 software (SPSS Inc, Chicago, IL). Debris extrusion in the same group was analyzed using the t test.

Teeth mounted in eppendorf microbalance tube



Preop eppendorf tube weighed using

RESULT

The mean weight, range, and standard deviation for each instrumentation group are presented in Table 1. Data were analyzed using a Mann Whitney U test of variance to determine whether a significant difference in the amount of apically extruded debris existed among the groups. Figure 1 indicates the mean comparison between ProFit S3 and Protaper NEXT for the amount of debris extruded.

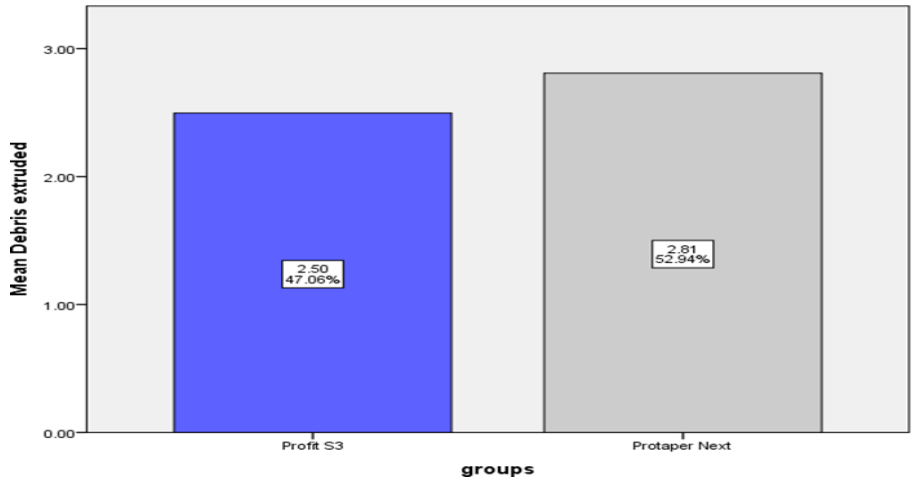


Figure 1 indicates the mean comparison between ProFit S3 and Protaper NEXT for amount of debris extruded

TABLE 1: indicates the mean comparison between ProFit S3 and ProTaper NEXT for amount of debris extruded.

	Groups	Mean	Standard deviation	P value
Debris extruded	ProFit s3	2.4957	0.27748	0.005
	ProTaper NEXT	2.808	0.13514	0.007

* The mean difference is significant at the 0.05 level.

DISCUSSION

This study discusses the phenomenon of apical extrusion of debris between two endodontic rotary file system.These files were chosen due to their similarity in cross-section both were rectangular cross section.The methodology utilized for the study has been used for several years to measure the amount of apically extruded debris in numerous studies of newly available preparation technologies that have been published in endodontic journals(23)(24)(25)(26)(18).These methods were reproducible and efficient, and it makes it simple to compare the results of one study to those of other studies, opening up the possibility to further meta-analyses involving various investigations.

The results of this research indicate that all of the instrumentation techniques examined result in apically extruded debris.For endodontic therapy to be effective, the root canal space should be biomechanically prepared. The full removal of bacteria, necrotic debris, and all necessary tissue from a root canal system is the goal(27)(12).

Extrusion of debris into the periapical tissues can be related to postoperative pain after endodontic instrumentation. The possible reasons for the debris extrusion may be due to the cross-sectional geometry of the file, instrumentation technique, motion of the file, irrigation system, or anatomy of the root and the cross section of this file shows similar cross-section.

ProTaper NEXT claims that ,one of the most recent generations of files, stands out with its offset centre of mass and centre of rotation. Compared to a file with a centered mass and axis of rotation, this design offers a larger cross sectional region for improved cutting, loading, and successfully permitting the debris to exit the canal coronally(28)(10).ProFit S3 rotary files it has a variable taper design with a rectangular cross-section. This cross-section has two-point contact, thereby reducing the apical extrusion of debris(3)(29).

In this study, we have used the most attention and has been adopted by most studies pertaining to apical extrusion of debris is the one described by Myers & Montgomery (1991).It is very likely that a smaller amount of extruded material may have a higher chance of eliciting a periapical response because it contains bacteria with higher virulence and antigenic characteristics than a

larger amount of extruded material but without the same level of irritation.According to Myers & Montgomer, filing to the foramen caused more debris to extrude than filing to the foramen that was 1 mm shorter (Martin & Cunningham 1982a,b, Myers & Montgomery 1991, Beeson et al. 1998).

Post-operative pain is one of the main drawbacks in root canal preparation.Bacteria, intracanal irrigants, or intracanal medications can also be pushed into the periradicular tissues and cause post-instrumentation irritation and pain in addition to dentin debris. Many studies have reported varying degrees of post endodontic pain ranging from 25-40%(30)(13).Main causes of postoperative discomfort was the extrusion of contaminated debris during chemomechanical preparation(11,30)(13,14). Result shows that profit S3 file show less debris extrusion when compared to ProTaper NEXT. Limitation of the study is further studies were required with increased sample size.

Our team has extensive knowledge and research experience that has translate into high quality publications (31–40)

CONCLUSION

The present study concluded that rotary file systems for root canal treatment are associated with apical extrusion of root canal dentin layer debris. In addition, the ProFit S3 files resulted in a comparatively lower amount of apical debris layer extrusion than the ProTaper Next rotary file systems.

REFERENCES

1. Ingle JI, Bakland LK. Endodontics [Internet]. 1994. 984 p. Available from: https://books.google.com/books/about/Endodontics.html?hl=&id=lBZqAAAAMAAJ
2. Berman LH, Hargreaves KM. Cohen's Pathways of the Pulp - E-Book [Internet]. Elsevier Health Sciences; 2020. 992 p. Available from: https://play.google.com/store/books/details?id=_9_7DwAAQBAJ
3. Antony SDP, Subramanian AK, Nivedhitha MS, Solete P. Comparative evaluation of canal transportation, centering ability, and dentin removal between ProTaper Gold, One Curve, and Profit S3: An study. J Conserv Dent [Internet]. 2020 Nov-Dec;23(6):632–6. Available from: http://dx.doi.org/10.4103/JCD.JCD_619_20
4. Antony DP, Senior Lecturer, Department of Conservative dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University. Comparative evaluation of canal transportation and centring ability of three rotary file systems - in-vitro study. Int J Dent Oral Sci [Internet]. 2021 Jul 17;3252–6. Available from: http://scidoc.org/articlepdfs/IJDOS/IJDOS-2377-8075-08-7068.pdf
5. de Paz LEC, Sedgley CM, Kishen A. The Root Canal Biofilm [Internet]. Springer; 2015. 366 p. Available from: https://play.google.com/store/books/details?id=EuXHCgAAQBAJ
6. Jeevanandan G, Govindaraju L, Subramanian EMG, Priyadarshini P. Comparative Evaluation of Quality of Obturation and Its Effect on Postoperative Pain between Pediatric Hand and Rotary Files: A Double-blinded Randomized Controlled Trial. Int J Clin Pediatr Dent [Internet]. 2021 Jan-Feb;14(1):88–96. Available from: http://dx.doi.org/10.5005/jp-journals-10005-1895
7. Solete P, Reader, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai. Comparative evaluation of dentin crack formation after root canal preparation using 3 different rotary files - invitro study. Int J Dent Oral Sci [Internet]. 2021 Jan 8;3209–13. Available from: http://scidoc.org/articlepdfs/IJDOS/IJDOS-2377-8075-08-7060.pdf
8. Torabinejad M, Kettering JD, McGraw JC, Cummings RR, Dwyer TG, Tobias TS. Factors associated with endodontic interappointment emergencies of teeth with necrotic pulps. J Endod [Internet]. 1988 May;14(5):261–6. Available from: http://dx.doi.org/10.1016/S0099-2399(88)80181-X
9. Siqueira JF Jr. Microbial causes of endodontic flare-ups. Int Endod J [Internet]. 2003 Jul;36(7):453–63. Available from: http://dx.doi.org/10.1046/j.1365-2591.2003.00671.x
10. Anjaneyulu, Reader, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, 600077, India. Association of irreversible pulpitis and single visit root canal treatment.

Int J Dent Oral Sci [Internet]. 2020 Nov 27;1127–31. Available from: https://scidoc.org/articlepdfs/IJDOS/IJDOS-2377-8075-07-11032.pdf

11. Wittgow WC Jr, Sabiston CB Jr. Microorganisms from pulpal chambers of intact teeth with necrotic pulps. J Endod [Internet]. 1975 May;1(5):168–71. Available from: http://dx.doi.org/10.1016/S0099-2399(75)80115-4
12. Sandeep AH, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, 600077, India. Incidence of re-root canal treatment in canines due to obturation short of apex - A retrospective study. Int J Dent Oral Sci [Internet]. 2020 Dec 18;1252–5. Available from: https://scidoc.org/articlepdfs/IJDOS/IJDOS-2377-8075-07-12020.pdf
13. Panchal V, Jeevanandan G, Subramanian E. Comparison of instrumentation time and obturation quality between hand K-file, H-files, and rotary Kedo-S in root canal treatment of primary teeth: A randomized controlled trial. J Indian Soc Pedod Prev Dent [Internet]. 2019 Jan-Mar;37(1):75–9. Available from: http://dx.doi.org/10.4103/JISPPD.JISPPD_72_18
14. Khandelwal A, Jose J, Teja KV, Palanivelu A. Comparative evaluation of postoperative pain and periapical healing after root canal treatment using three different base endodontic sealers - A randomized control clinical trial. J Clin Exp Dent [Internet]. 2022 Feb;14(2):e144–52. Available from: http://dx.doi.org/10.4317/jced.59034
15. Troiano G, Dioguardi M, Cocco A, Giuliani M, Fabiani C, D'Alessandro A, et al. Centering Ability of ProTaper Next and WaveOne Classic in J-Shape Simulated Root Canals. ScientificWorldJournal [Internet]. 2016 Dec 8;2016:1606013. Available from: http://dx.doi.org/10.1155/2016/1606013
16. Haridas K, Hariharan M, Singh P, Varughese A, Ravi AB, Varma KR. Effect of instrumentation techniques and kinematics on apical extrusion of debris: An in vitro study. J Contemp Dent Pract [Internet]. 2019 Sep 1;20(9):1067–70. Available from: https://www.thejcdp.com/doi/10.5005/jp-journals-10024-2656
17. Mamede-Neto I, Borges AH, Guedes OA, de Oliveira D, Pedro FLM, Estrela C. Root Canal Transportation and Centering Ability of Nickel-Titanium Rotary Instruments in Mandibular Premolars Assessed Using Cone-Beam Computed Tomography. Open Dent J [Internet]. 2017 Feb 14;11:71–8. Available from: http://dx.doi.org/10.2174/1874210601711010071
18. Lakshmanan L, Somasundaram S, Jeevanandan G, Subramanian E. Evaluation of Postoperative Pain after Pulpectomy using Different File Systems in Primary Teeth: A Systematic Review. Contemp Clin Dent [Internet]. 2021 Mar 20;12(1):3–8. Available from: http://dx.doi.org/10.4103/ccd.ccd_561_20
19. Tambe V, Nagmode P, Abraham S, Patait M, Lahoti P, Jaju N. Comparison of canal transportation and centering ability of rotary protaper, one shape system and wave one system using cone beam computed tomography: An in vitro study [Internet]. Vol. 17, Journal of Conservative Dentistry. 2014. p. 561. Available from: http://dx.doi.org/10.4103/0972-0707.144605
20. Nandakumar M, Nasim I. Effect of intracanal cryotreated sodium hypochlorite on postoperative pain after root canal treatment - A randomized controlled clinical trial. J Conserv Dent [Internet]. 2020 Nov 5;23(2):131–6. Available from: http://dx.doi.org/10.4103/JCD.JCD_65_20
21. Antony SP, Subramanian A, Nivedhitha MS, Solete P. Comparative evaluation of canal transportation, centering ability, and dentin removal between ProTaper Gold, One Curve, and Profit S3: An in vitro study [Internet]. Vol. 23, Journal of Conservative Dentistry. 2020. p. 632. Available from: http://dx.doi.org/10.4103/jcd.jcd_619_20
22. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. J Endod [Internet]. 1991 Jun;17(6):275–9. Available from: http://dx.doi.org/10.1016/S0099-2399(06)81866-2
23. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod [Internet]. 2012 Jun;38(6):850–2. Available from: http://dx.doi.org/10.1016/j.joen.2012.02.017
24. Bürklein S, Börjes L, Schäfer E. Comparison of preparation of curved root canals with Hyflex CM and Revo-S rotary nickel-titanium instruments. Int Endod J [Internet]. 2014 May;47(5):470–6. Available from: http://dx.doi.org/10.1111/iej.12171
25. Üstün Y, Çanakçi BC, Dinçer AN, Er O, Düzgün S. Evaluation of apically extruded debris associated with several Ni-Ti systems.

Int Endod J [Internet]. 2015 Jul;48(7):701–4. Available from: http://dx.doi.org/10.1111/iej.12369

26. Teja KV, Ramesh S, Vasundhara KA. Comparative Evaluation of Preemptive and Preventive Analgesic Effect of Oral Ibuprofen in Single Visit Root Canal Treatment- A Prospective Randomised Pilot Study. Eur Endod J [Internet]. 2022 Jun;7(2):106–13. Available from: http://dx.doi.org/10.14744/eej.2021.49469
27. Goldman M, White RR, Moser CR, Tenca JI. A comparison of three methods of cleaning and shaping the root canal in vitro. J Endod [Internet]. 1988 Jan;14(1):7–12. Available from: http://dx.doi.org/10.1016/s0099-2399(88)80235-8
28. Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endod [Internet]. 1998 Mar;24(3):180–3. Available from: http://dx.doi.org/10.1016/S0099-2399(98)80179-9
29. Ms N, Professor and Head, Department of Conservative Dentistry and Endodontics, Clinical Genetics Lab, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University. Postoperative pain associated with resin and bioceramic based sealers: A systematic review. Int J Dent Oral Sci [Internet]. 2021 Aug 2;3613–9. Available from: https://scidoc.org/articlepdfs/IJDOS/IJDOS-2377-8075-08-809.pdf
30. Bartols A, Laux G, Walther W. Multiple-file vs. single-file endodontics in dental practice: a study in routine care. PeerJ [Internet]. 2016 Dec 7;4:e2765. Available from: http://dx.doi.org/10.7717/peerj.2765
31. Neelakantan P, Grotra D, Sharma S. Retreatability of 2 mineral trioxide aggregate-based root canal sealers: a cone-beam computed tomography analysis. J Endod [Internet]. 2013 Jul;39(7):893–6. Available from: http://dx.doi.org/10.1016/j.joen.2013.04.022
32. Aldhuwayhi S, Mallineni SK, Sakhamuri S, Thakare AA, Mallineni S, Sajja R, et al. Covid-19 Knowledge and Perceptions Among Dental Specialists: A Cross-Sectional Online Questionnaire Survey. Risk Manag Healthc Policy [Internet]. 2021 Jul 7;14:2851–61. Available from: http://dx.doi.org/10.2147/RMHP.S306880
33. Sheriff KAH, Ahmed Hilal Sheriff K, Santhanam A. Knowledge and Awareness towards Oral Biopsy among Students of Saveetha Dental College [Internet]. Vol. 11, Research Journal of Pharmacy and Technology. 2018. p. 543. Available from: http://dx.doi.org/10.5958/0974-360x.2018.00101.4
34. Markov A, Thangavelu L, Aravindhan S, Zekiy AO, Jarahian M, Chartrand MS, et al. Mesenchymal stem/stromal cells as a valuable source for the treatment of immune-mediated disorders. Stem Cell Res Ther [Internet]. 2021 Mar 18;12(1):192. Available from: http://dx.doi.org/10.1186/s13287-021-02265-1
35. Jayaraj G, Ramani P, Herald J. Sherlin, Premkumar P, Anuja N. Inter-observer agreement in grading oral epithelial dysplasia – A systematic review [Internet]. Vol. 27, Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology. 2015. p. 112–6. Available from: http://dx.doi.org/10.1016/j.ajoms.2014.01.006
36. Paramasivam A, Priyadharsini JV, Raghunandhakumar S, Elumalai P. A novel COVID-19 and its effects on cardiovascular disease. Hypertens Res [Internet]. 2020 Jul;43(7):729–30. Available from: http://dx.doi.org/10.1038/s41440-020-0461-x
37. Li Z, Veeraraghavan VP, Mohan SK, Bolla SR, Lakshmanan H, Kumaran S, et al. Apoptotic induction and anti-metastatic activity of eugenol encapsulated chitosan nanopolymer on rat glioma C6 cells via alleviating the MMP signaling pathway [Internet]. Vol. 203, Journal of Photochemistry and Photobiology B: Biology. 2020. p. 111773. Available from: http://dx.doi.org/10.1016/j.jphotobiol.2019.111773
38. Gan H, Zhang Y, Zhou Q, Zheng L, Xie X, Veeraraghavan VP, et al. Zingerone induced caspase-dependent apoptosis in MCF-7 cells and prevents 7,12-dimethylbenz(a)anthracene-induced mammary carcinogenesis in experimental rats. J Biochem Mol Toxicol [Internet]. 2019 Oct;33(10):e22387. Available from: http://dx.doi.org/10.1002/jbt.22387
39. Dua K, Wadhwa R, Singhvi G, Rapalli V, Shukla SD, Shastri MD, et al. The potential of siRNA based drug delivery in respiratory disorders: Recent advances and progress. Drug Dev Res [Internet]. 2019 Sep;80(6):714–30. Available from: http://dx.doi.org/10.1002/ddr.21571
40. Mohan M, Jagannathan N. Oral field cancerization: an update on current concepts. Oncol Rev [Internet]. 2014 Mar 17;8(1):244. Available from: http://dx.doi.org/10.4081/oncol.2014.244