ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2025; 11(1): 115-118

www.oraljournal.com
Received: 17-11-2024
Accepted: 22-12-2024

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A review on effects of sterilization procedure on cyclic fatigue and cutting efficiency of endodontic instrument

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DOI: https://doi.org/10.22271/oral.2025.v11.i1b.2110

Abstract
Aim: The purpose of the study is to analyze and evaluate effects of sterilization procedure on cyclic fatigue and cutting efficiency of various endodontic instruments.
Materials and Methods: Various comprehensive articles were searched and collected upto October 2024. Data were analysed and certain protocol on effects of sterilization techniques and cutting efficiency of endodontic files were summarized.
Result: Several searched term include autoclave, sterilization, cyclic fatigue, cutting efficiency in pubmed. Studies reported that endodontic files which have been treated with repeated sterilization have significantly reduced cyclic fatigue and tortional effect. As for cutting efficiency endodontic files tend to have increased resistance depending on number of cycles and endodontic files standardization system.
Conclusion: Analysis have shown that various effects due to sterilization procedures results in changes on the physical and mechanical properties of endodontic instruments.

Keywords: Sterilization, autoclave, cyclic fatigue, cutting efficiency, torsional effect

Introduction
Sterilization plays important role for proceeding with the reuse of endodontic instruments. Sterilization has the purpose of breaking down and eliminating all microorganisms, viruses, and spores and preventing cross infections [1]. It includes several phases: pre-sterilization, drying, packaging, heat sterilization, and storage of the sterile material [2]. Pre-sterilization consist of disinfection, decontamination, and cleaning of the dental instruments. The purpose of decontamination is to achieve a reduction in the microbial load, while cleansing aims to remove organic and inorganic residues from endodontic instruments [3]. The subsequent phases involve the rinsing, drying, and packaging of instruments followed by heat sterilization (Autoclave at 134 °C at 2 bar) to eliminate spores. The last phase is storage of instruments [4]. Even though sterilisation procedure inhibits growth of microorganisms, repeated procedures causes fractures of instruments which raises concerns over reuse of instruments. Zhao *et al*. (2016) reports, as regards HyFlex CM, Twisted File, and K3XF instruments (autoclave sterilization performed at 134 °C with a pressure of 30 psi for 5 min), an increase in resistance to cyclic fatigue [5]. Viana *et al*. (2006) reports an average of cycle numbers (916-950 cycles to failure) associated with higher failure in heat-sterilized profiles [6]. These are in contrast with recent study conducted by Masoud Khabiri *et al*. (2017) on NiTi instruments, which reported no influence on cyclic fatigue [7], while Silvaggio and Hicks (1997) demonstrate that 10 autoclave cycles do not increase the risk of fracture in profiles [8]. Therefore, our present study is based on each effects of sterilisation on cyclic fatigue and cutting efficiency.

Materials and Methods
A group of literature were searched and collected upto October 2024 which were previously published by several authors. Multiple studies on same researched area was found and ultimately articles which were similar with study outcome was included.

Inclusion: Previously published articles on effects of sterilization on endodontic files and its outcome.

Exclusion: Those articles which were not based on effects and cutting efficiency after sterilization were not included.
Studies were verified and included through certain searched terms found in Pubmed Scopus and google.
After thorough discussion two independent authors screened and included studies which fulfilled study criteria. Searched terms were autoclave, sterilization, endodontic files, pre sterilization, disinfectants, cyclic fatigue, cutting efficiency. Two independent researchers did a thorough identification and verified included articles. Those articles which were considered insufficient in reporting data on influence of sterilization on cutting efficiency and depth of cut were not included.

Results

A total of 100 articles were searched on Pubmed, Scopus and google scholar. After achieving identified articles and those articles which were restricted according to year of publication a total of 15 records were found. Among the articles 8 articles were included for the analysis and represented in a flowchart.

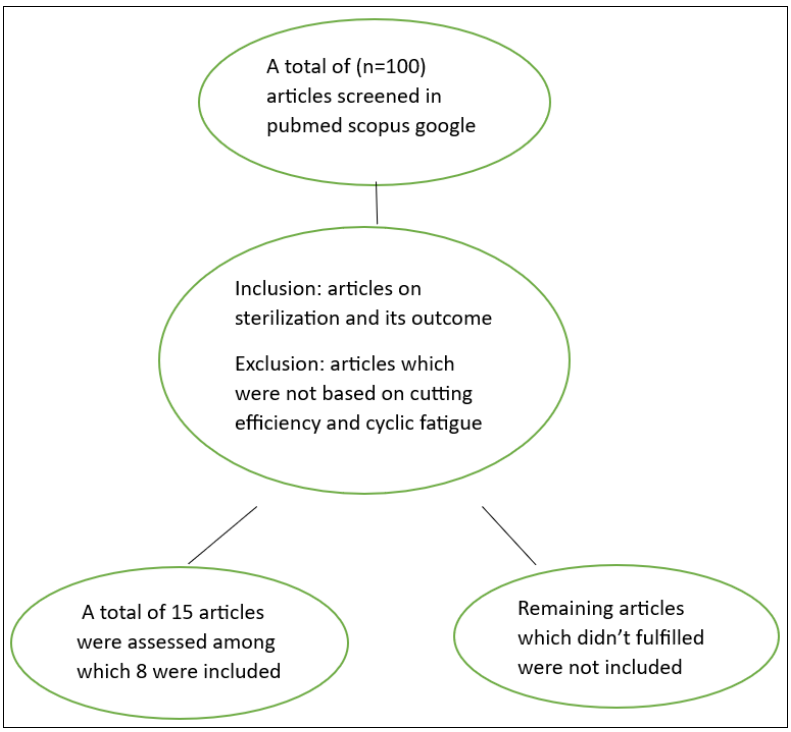

Fig 1: Flow chart on selection of eligible studies

Characteristics of studies focusing on the cutting efficiency of endodontic instruments in relation to sterilization procedures

Authors	Type of study	Instruments	Number of cycles	Time and temperature	Results
Morrison *et al*. 1989	Meta analysis *In vitro*	stainless steel #25 Flexofile	1 after use 1 molar 5 after use 10 after use 10 molar	15 min, 121 °C	No significant difference in cutting efficiency
Schafer *et al*. 2002 [12]	Meta analysis *In vitro*	NiTi Kfile 35# NiTi Kfile PVD 35#	5 + NaOCl treatment 5 + NaOCl treatment	30 min, 134 °C	50.6-16.1% NiTi Kfile (10-5 cycles)
Neal *et al*. 1983 [13]	Meta analysis *In vitro*	K-type #30 stainless steel files stainless steel Unifile #30	10 5, 10	30 min, 270 °F	Autoclave sterilization resulted in a small but significant decrease in cutting ability of the files
Haikel *et al*. 1996 [14]	Meta analysis *In vitro*	stainless steel Unifile #30 H-file #30 Flexofile #30	5,10	30 min, 131 °C	Unifile and Flexofile, a cutting efficiency reduction (range of 20% to 70%)
Rapisarda *et al*. 1999 [15]	Meta analysis *In vitro*	NiTi ProFile instruments (#15, #30 #40 #45)	7,14	30 min, 121 °C	The number of sterilization cycles was a determining factor as to cutting efficiency
Seago *et al*. 2015 [16]	Meta analysis *In vitro*	NiTi Hyflex CM Rotary Files 35#	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 cycles	6 min, 132 °C	No statistical decrease after 1, 4, 5, and 6 cycles.
Emad O Alshwaimi 2019 [17]	Meta analysis *In vitro*	Proflexendo rotary files (40/0.04, 30/0.04 20/0.06)	0,2,5,10 cycles	134 °C for 25 min	The non-sterilized size 30/0.04 files had the highest cycles to failure, followed by the non-sterilized size 40/0.04 and 20/0.06 files ($p< 0.001$).
Taha ozyurek *et al*.	*In vitro*	ProTaper Universal, ProTaper Next, and ProTaper Gold nickel-titanium instruments	10	18 minutes under 30 psi of pressure at 134 °C and then dried for 30 minutes	When compared with PTU and PTN files, PTG files were significantly resistant to cyclic fatigue ($p< 0.05$). In addition, PTN files were significantly more resistant to cyclic fatigue than PTU files ($p< 0.05$).

Discussion

Disinfection and sterilization procedures of the endodontic instruments varies depending on the material (through hot sterilization procedures, which require the use of the autoclave). Morrison *et al.* have stated that through variable number of sterilisation cycles, no significant difference was found in cutting efficiency [9].

Filho *et al*. stated the need to remove metal residues from endodontic files prior to clinical use or sterilization [10]. Hauptman *et al*. also demonstrated the presence of microorganisms (*P. lentimorbus*), even in the presence of instruments supplied as sterile by the manufacturing industries. The presence of these microorganisms underlines how important it is to decontaminate the instruments before use, which do not, however, require sterilization by heat that may alter their physical, mechanical, and surface properties [11].

Data on high heterogeneity is also reported by Schafer *et al*. (2002) on two different types of instruments (NiTi Kfile, NiTi Kfile PVD). Analysis shows Reduction in the cutting angle and of the resistance of endodontic instruments in steel subjected to the autoclave and partially for NiTi and as for Effect of Sterilization on Cutting Efficiency study by Schafer *et al*. showed that there is a reduction in cutting efficiency in the NiTi K files equal to 16.1% after five sterilization cycles and 50.8% after 10 sterilization cycles by autoclave at a temperature of 135 [12]. Similarly, Neal *et al*. [13] described a small but significant decrease in the cutting capacity of files (K-type 30 #) after 10 autoclaving cycles, on the cutting efficiency of stainless-steel endodontic instruments as affected by autoclaving. Haïkel *et al*. found, using the Unifile and Flexofile, a cutting efficiency reduction (range of 20% to 70%) from five to 10 autoclave cycles [14]. Rapisarda *et al*. reported that there is a reduction in cutting efficiency even for rotary NiTi tools used for shaping, such as profiles. In their study, the reduction in cutting efficiency was 20% for seven cycles and 50% for 14 cycles (hot sterilization). Rapisarda *et al*. indicate the formation of NiTi oxides on the surface as a mechanism for the loss of cutting efficiency. Therefore, according to the authors, the phenomenon must be related to the corrosion induced by the oxidation of the surface layers [15]. However, Seago *et al*., in apparent contrast with the previous studies, do not notice any statistically significant reduction of the cutting efficiency on Hflex (NiTi instruments) for sterilization procedures by autoclave (1-2 cycles) [16]. Emad *et al.* reported that the nonsterilized size 30/0.04 files had the highest cycles to failure, followed by the nonsterilized size 40/0.04 and 20/0.06 files ($p< 0.001$). With increasing rounds of sterilization, cycles to failure reduced for sizes 40 (2×, 5× and 10×) and 30 (2×) files compared with nonsterilized sizes 40 ($p< 0.05$) and 30 files ($p< 0.001$), respectively [17]. Taha *et al*. reported PTG showed significantly higher Number of Cycles to Failure than PTU and PTN in group 1 ($p< 0.05$). Sterilization significantly increased the NCF of PTN and PTG ($p< 0.05$) in group 2. PTN in group 3 had significantly higher cyclic fatigue resistance than PTN group 4 ($p< 0.05$). Also, significantly higher NCF was observed for PTG in group 2 than in groups 3 and 4 ($p < 0.05$) [18].

Conclusion

The present analysis have shown that various effects due to sterilization procedures results in changes on the physical and mechanical properties of endodontic instruments. However further studies and research investigations on such topic is required for more accurate findings.

Source of funding

Nil

Conflict of interest

Nil

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How to Cite This Article
Singgam S, Lisam B. A review on effects of sterilization procedure on cyclic fatigue and cutting efficiency of endodontic instrument. International Journal of Applied Dental Sciences. 2025; 11(1): 115-118.