# Sterilization in Endodontic Instruments

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Sterilization processes guarantee the sterility of dental instruments but can negatively affect instrument features by altering their physical and mechanical properties. The endodontic instrumentation can undergo a series of alterations, ranging from corrosion to variation in the cutting angle and then changes in the torsional properties and torsional fatigue resistance.

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## 1. Introduction

The sterilization of endodontic instruments represents an important process 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].

The sterilization process includes several phases: pre-sterilization, drying, packaging, heat sterilization, and storage of the sterile material [2].

Pre-sterilization consists in the disinfection, decontamination, and cleaning of the dental instruments. This phase involves disinfection either by immersion of the instruments with decontaminating and disinfecting liquids or by washing with vanish disinfectors. 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 (to avoid the removal of debris through hand-brushing, the use of ultrasonic trays is recommended) [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 the instruments [4].

The fracture of endodontic instruments inside the canal is a problem that is not always easy to resolve [5]. The possibility of reusing many endodontic instruments after sterilization procedures raises the question of how much these procedures can influence the physical and mechanical properties, with three possible answers: a worsening, an improvement, or no effect [6].

The literature is not in agreement that there is an absolute lack of influence of procedures on instrument properties. 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 [7]. Viana et al. (2006) reports an average of cycle numbers (916–950 cycles to failure) associated with higher failure in heat-sterilized profiles [8]. These are in contrast with recent study conducted by Masoud Khabiri et al. (2017) on NiTi instruments, which reported no influence on cyclic fatigue [9], while Silvaggio and Hicks (1997) demonstrate that 10 autoclave cycles do not increase the risk of fracture in profiles [10]. Resistance to cyclic fatigue is not the only physical and mechanical property affected by sterilization procedures—e.g., there is also the resistance to torsional fatigue, about which recent studies disagree with respect to improvement, as stated by Casper et al. using M Wire alloys, and the deterioration, as reported by King et al. using the Gt x series [11][12]. Furthermore, sterilization procedures can negatively affect the cutting efficiency and create corrosive effects on the surface of instruments, as demonstrated in a 2018 study by Nashwan-Ahmed Qaed et al., which reports a reduction in the cutting angle and surface modifications using Revo S instruments subjected to autoclaving [13].

Scientific studies therefore report conflicting opinions on the alterations affecting endodontic instruments subject to sterilization procedures. This divergence of opinions and results could depend on the countless instruments and protocols used in endodontics and on the different sterilization and disinfection methods [1].

## 2. Sterilization Methods

The disinfection and sterilization procedures of the endodontic instruments can vary depending on the material, whether they are single-use or reusable (through hot sterilization procedures, which require the use of the autoclave) [14].

The first-use instruments must necessarily undergo a cleansing and decontamination phase to remove metal residues (chromium nickel residues present on the surface deriving from the production processes) [15]. In fact, Filho et al. stated the need to remove metal residues from endodontic files prior to clinical use or sterilization [16]. 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 [17].

These operations can be performed with the use of an ultrasonic bath or a disinfected tray and with a few minutes of immersion in disinfectant solutions such as 2% chlorhexidine or 2% peracetic acid [18].

These first-use or non-autoclavable instruments, after being rinsed with distilled water, are dried, packaged, and ready for clinical use [1].

The reusable instruments used for the various operational phases, such as scouting glide path and channel shaping, present critical issues (not only related to the influence of the mechanical and physical properties), such as the risk of cross-infection for health workers or patients, and the risk related to the presence of nonviral and nonbacterial contaminants, such as prions of human spongiform encephalopathy [19]. We recall that prions are only partially inactivated by normal sterilization procedures (autoclave). In fact, it is known that the manual removal of residues between the blades is ineffective without ultrasound. Moreover, the hand-brushing procedure presents a greater risk of cross-infection for decontamination and disinfection operators [20].

Heat sterilization can be performed using 3 different methods:Steam sterilization (autoclaves): The dried and packaged instruments undergo a heating cycle (transmitted through the steam that penetrates the packaging) that can vary from 134 °C to 121 °C for a period of time that can vary from 5 min to 30 min [21][22][23].

Dry heat sterilization: The heat is not transmitted through the steam but through the air that can be forced to circulate at a temperature of 190 °C for a period of time ranging from 5 min to 15 min up to 2–4 h, dependent on the packaging method (metallic packages or packages out of plastic laminates that can withstand much heat) [24].

Sterilization by chemical steam (chemiclaves): A sterilizing agent is used, and a chemical steam (alcohol and formaldehyde) is suitably heated. The sterilization cycle is 20 min at 134 °C [22][23].

Most of the instruments are autoclavable at a temperature of both 120 °C and 135 °C but must first undergo a decontamination phase for the removal of residues and microorganisms (ultrasound trays or vanish disinfectors with the combined use of detergents and disinfectants) [25], followed by washing with distilled water, drying, and packaging [1].

Endodontic instruments can be influenced by sterilization and disinfection processes at various times. The analysis of the literature shows how these alterations can come from two phases:

- The disinfection phase, by physical chemical action by decontaminating agents [26].
- The sterilization phase, by autoclave for temperature action [27].

These two phases determine the major influences on metal endodontic instruments.

The effects can be summarized as follows:

- Corrosive effects both from disinfectant agents (sodium hypochlorite) with the phenomenon of micropitting, and from oxygen, with the formation of NiTi oxides under thermal stress in an autoclave [28].
- An increase in surface roughness of the surface in nickel titanium following autoclave sterilization [29].
- Partial recovery of macroscopic deformities in NiTi instruments after sterilization treatment in the autoclave [30].
- Partial recovery of cyclic fatigue suffered by NiTi instruments (most but not all studies) in the autoclave [31].
- Partial recovery of the torsional stress of the NiTi instruments, but not the totality of the studies, in the autoclave [32].

- Reduction in the cutting angle and of the resistance of endodontic instruments in steel subjected to the autoclave and partially for NiTi [33].
- Reduction in cutting efficiency (untreated NiTi alloys during the manufacturing process with hot procedures) [34][35].

## 3. Effect of Sterilization on Cutting Efficiency

One of the effects of sterilization procedures is the reduction in the cutting efficiency of the instruments. A 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°. The same study draws attention to the fact that treatment with sodium hypochlorite at a concentration equal to 5.25% for 30 min has no effect on the reduction of cutting efficiency [33].

The data reported in the studies by Haikel et al. in 1996 and 1998 are similar. In this case, for sodium hypochlorite applied from 12 h to 48 h at 2.5% and ultrasonic cleaning baths, a reduction in cutting efficiency was reported for both single rows and flex on the file, with percentages ranging from 20% to 60% [36][37]. A minimal reduction in the cutting efficiency was also noted for glass bead sterilization and for dry hot sterilization for cycles of 5 or 10 min [37]. In this study, unifiles are endodontic files that have less reduction in cutting efficiency after sterilization procedures.

Morrisoon et al. tested K steel files following the use of extracted teeth and autoclave sterilization. The authors came to the conclusion that there is no reduction in the depth of the cut following five autoclave cycles and that the reduction is due only to clinical use [38].

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