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Short Communication

Effects of Autoclaving on Dimensional Qualities and Physical Properties (Flexural Rigidity and Brittleness) of Newly Developed Root Canal Filling Point Made of Polypropylene (FLEX POINT NEO®)

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Abstract

In this study, we investigated the effects of 10 cycles of conventional autoclaving (121°C, 20 min) on the dimensional integrity and physical properties (flexural rigidity and brittleness) of a newly developed root canal filling point made of polypropylene (FLEX POINT NEO®). We measured the diameters of autoclave-sterilized and non-treated polypropylene points (020 through 070) and calculated the incidence of deviation from ISO specifications (6877.4.4.1, 1995). In order to ascertain physical properties, we tested autoclave-sterilized and non-treated polypropylene points (030, 050 and 070) for flexural rigidity. This was done by evaluating deflection value when a load was placed at the free tip-end of the point and brittleness in accordance with ISO specifications (6877.6.5.2).

Ten cycles of autoclaving showed no significant effect on the diameters of the polypropylene points. All the polypropylene points in both the non-treated and the autoclave-sterilized groups met ISO specifications in terms of dimensional integrity of diameter. In the autoclave-sterilized group, 030 and 050 polypropylene points showed a slight decrease in flexural rigidity (3.4% in 030, 10.0% in 050). In terms of brittleness, none of polypropylene points showed any sign of fracture.

Key words: Polypropylene root canal filling point—Dimensional accuracy—
Physical property—Autoclaving

Introduction

Offering many advantages, gutta-percha

points are widely used to fill root canals^{4,9)}. However, some endodontists have pointed out that such points sometimes fail to meet

ISO specifications in terms of accuracy of size^{14,18}) and that they lack sufficient rigidity to allow introduction into a narrow or curved root canal^{4,9}). A further clinical problem is that such thermoplastic gutta-percha points can not be sterilized by conventional autoclaving, a popular method in dental clinics, as it is effective against all types of micro-organism^{19,24}). Therefore, gutta-percha points have to be disinfected by various chemical agents before use^{1-3,6,10,16,20,22,23,25}). Polypropylene is a plastic that has been used in a number of clinical fields as a safe material for implant devices or indwelling catheters because of its chemical stability *in vivo*^{9,14}). In 1963 Grossman⁸) developed an experimental root canal filling point which was made of polypropylene containing bismuth subcarbonate for radiopacity. However, the products were unsuitable for practical use as they were dimensionally defective.

The authors of this paper and NEO Dental Chemical Products Corporation have jointly developed a root canal filling point (FLEX POINT NEO[®]) made of polypropylene (30% w/w) adding a barium sulfate (70% w/w) as the contrast medium (polypropylene point).

The aim of this study was to assess the effect of conventional autoclaving on the dimensional and physical properties (flexural rigidity and brittleness) of polypropylene points.

Materials and Methods

In order to determine dimension, sizes 020, 025, 030, 040, 050, 060 and 070 polypropylene points (NEO Dental Chemical Products Co., LTD.) were chosen at random (20 of

each size). To ascertain physical properties, sizes 030, 050 and 070 polypropylene points were chosen at random (10 of each size). The points were divided into autoclaving and non-treated groups in each size for both measurements.

The points in the autoclaving groups were put in a dedicated autoclave-resistant container made of polypropylene (heat resistance: 158°C), and sterilized over 10 cycles in an autoclave (AC-23 ALPSE Co., LTD.) by the conventional method (121°C, 20 min).

All procedures were carried out at room temperature $20 \pm 2^\circ\text{C}$ at a humidity of $50 \pm 5\%$.

1. Measurement of diameter of points

The diameters of the polypropylene points at d1, d2, and d3 (Fig. 1) were determined using a photoelectric test device (VM-8040 Kience Co., LTD.) according to the method recommended under ISO 6877:6.4 specifications¹³). The counter was accurate up to ± 0.001 mm. Values were calculated as the means value, SD and range. The number of points that fell within the tolerance limit range as specified by ISO 6877:4.4.1 specifications¹³) was then calculated. For the diameter of polymeric points, the ISO³) requires that all of any 10 samples chosen at random must be within a tolerance of ± 0.05 mm for sizes 010 to 025 and ± 0.07 mm for sizes 030 to 140.

2. Flexural rigidity as evaluated by deflection and brittleness of points

The flexural rigidity of the points was evaluated in terms of deflection value when a load was placed at the free tip-end of the points (Fig. 2). The point was fixed at a position

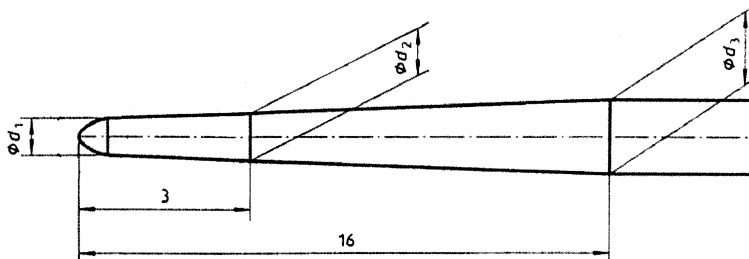


Fig. 1 Measure points for diameter (d1, 2, 3) of polypropylene point

25 mm from the tip using a DT-30 dial tension gauge (Tokyo Seiki Co., LTD). A concentrated load of 19.6 mN ($N=9.8$ kgf) was then applied at the free-end of the tip and the amount of deflection (mm) at that position measured.

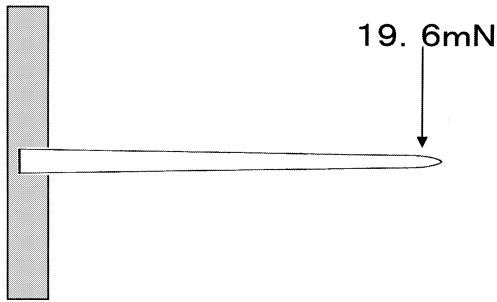


Fig. 2 Flexural rigidity of polypropylene points as evaluated by degree of deflection under concentrated load (19.6 mN) placed at free tip-end of point

The apparatus had a testing accuracy of 14 mm.

In order to ascertain brittleness, testing was carried out in accordance with ISO 6877:6.5.2 specifications¹³⁾. Using a testing apparatus designed to measure brittleness (H1-001A Japan Void Co.), the points were bent at the tip end alternately clockwise 30° and anti-clockwise through 5 mm, 20 times. They were then checked for the presence of fractures.

The mean value was compared using a *t* test at 95% significance levels.

Results

1. Diameters

The results for the diameters of the polypropylene points are summarized in Table 1, together with the ISO-specified tolerance

Table 1 Means (mm), standard deviations and range (mm) of diameter of polypropylene points after autoclaving

		d1	d2	d16
Size no.		Mean ± SD (range)	Mean ± SD (range)	Mean ± SD (range)
020	Non-treated	0.22 ± 0.005 (0.23–0.22)	0.27 ± 0.003 (0.28–0.27)	0.54 ± 0.013 (0.56–0.52)
	Autoclaving	0.22 ± 0.003 (0.23–0.22)	0.27 ± 0.003 (0.28–0.27)	0.55 ± 0.007 (0.56–0.54)
	ISO tolerance	0.20 ± 0.05 (0.25–0.15)	0.26 ± 0.05 (0.32–0.21)	0.52 ± 0.05 (0.57–0.47)
025	Non-treated	0.29 ± 0.007 (0.29–0.27)	0.34 ± 0.007 (0.35–0.33)	0.60 ± 0.008 (0.61–0.58)
	Autoclaving	0.29 ± 0.007 (0.30–0.27)	0.34 ± 0.007 (0.35–0.33)	0.61 ± 0.011 (0.62–0.59)
	ISO tolerance	0.25 ± 0.05 (0.30–0.20)	0.31 ± 0.05 (0.36–0.26)	0.57 ± 0.05 (0.62–0.52)
030	Non-treated	0.31 ± 0.009 (0.32–0.30)	0.37 ± 0.006 (0.38–0.36)	0.63 ± 0.007 (0.64–0.61)
	Autoclaving	0.31 ± 0.008 (0.32–0.30)	0.37 ± 0.005 (0.38–0.36)	0.64 ± 0.005 (0.64–0.63)
	ISO tolerance	0.30 ± 0.07 (0.37–0.23)	0.36 ± 0.07 (0.43–0.29)	0.62 ± 0.07 (0.69–0.55)
040	Non-treated	0.38 ± 0.009 (0.40–0.37)	0.45 ± 0.007 (0.47–0.44)	0.71 ± 0.003 (0.71–0.70)
	Autoclaving	0.37 ± 0.016 (0.38–0.36)	0.45 ± 0.016 (0.46–0.41)	0.70 ± 0.012 (0.71–0.68)
	ISO tolerance	0.40 ± 0.07 (0.47–0.33)	0.46 ± 0.07 (0.53–0.39)	0.72 ± 0.07 (0.79–0.65)
050	Non-treated	0.48 ± 0.010 (0.49–0.46)	0.55 ± 0.009 (0.57–0.54)	0.82 ± 0.008 (0.83–0.80)
	Autoclaving	0.47 ± 0.009 (0.49–0.45)	0.55 ± 0.008 (0.57–0.54)	0.82 ± 0.005 (0.83–0.81)
	ISO tolerance	0.50 ± 0.07 (0.57–0.43)	0.57 ± 0.07 (0.64–0.50)	0.82 ± 0.07 (0.89–0.75)
060	Non-treated	0.57 ± 0.012 (0.59–0.55)	0.66 ± 0.006 (0.67–0.65)	0.92 ± 0.009 (0.94–0.90)
	Autoclaving	0.57 ± 0.014 (0.59–0.55)	0.65 ± 0.017 (0.68–0.62)	0.91 ± 0.012 (0.94–0.89)
	ISO tolerance	0.60 ± 0.07 (0.67–0.53)	0.67 ± 0.07 (0.74–0.60)	0.92 ± 0.07 (0.99–0.85)
070	Non-treated	0.69 ± 0.014 (0.71–0.66)	0.77 ± 0.010 (0.79–0.75)	1.00 ± 0.014 (1.01–0.97)
	Autoclaving	0.68 ± 0.014 (0.71–0.66)	0.77 ± 0.011 (0.79–0.75)	1.00 ± 0.010 (1.02–0.98)
	ISO tolerance	0.70 ± 0.07 (0.77–0.63)	0.77 ± 0.07 (0.84–0.70)	1.02 ± 0.07 (1.09–0.95)

$n=10$ in each size of each group

ISO: nominal sizes and tolerance limits for diameters of standardized points; ± 0.05 for polymeric points of sizes 010 to 025 and ± 0.007 for sizes 030 to 070 (ISO 6877 1955).

limits for nominal sizes.

No significant difference was found in any of the sizes tested in terms of mean value of diameters between the autoclaving and the non-treated groups. The SD was small in all sizes for both groups. All the polypropylene points in both groups were within the ISO specified range for size.

2. Flexural rigidity as evaluated by deflection and brittleness of points

Ten cycles of autoclaving produced a significant increase in the degree of deflection for 030 and 050 points, as shown in Table 2. The degree of deflection is in inverse proportion to the degree of flexural rigidity. Therefore, the value given in Table 2 indicates that autoclave sterilization slightly decreased flexural rigidity in the polypropylene points in sizes 030 and 050, but produced no significant change in 070.

As shown in Table 3, none of the points showed any sign of fracture in the brittleness test.

Discussion

Root canal filling points must remain in root canals over a long period of time, and therefore must be able to withstand rigorous sterilization procedures such as autoclaving. In this study, we evaluated how the dimensional integrity and physical properties of newly-developed polypropylene points were affected by conventional autoclaving.

Table 2 Deflection (mm) at free end of points measured under application of concentrated load 19.6 mm N (kgf 9.8m/s)

	Polypropylene points	
	Non-treated	Autoclaving
	Mean \pm SD (range)	Mean \pm SD (range)
030	3.31 \pm 0.11 (3.45–3.17)	3.54 \pm 0.07 (3.63–3.45)
050	1.85 \pm 0.06 (1.93–1.79)	2.06 \pm 0.07 (2.09–1.95)
070	1.41 \pm 0.04 (1.45–1.37)	1.41 \pm 0.08 (1.48–1.28)

n = 5 in each size of each group

Endodontic technique presupposes that root-canal filling points are standardized to correspond with the dimensions and forms of standardized files and reamers^{11,12,15,17,18,26}. Therefore, the ISO requires strict accuracy with regard to the dimensions of root canal filling points and in 1994, the European Society of Endodontology⁵ named dimensional stability as one of the prerequisites for materials used to obturate the root canal system. However, a lack of standardization and dimensional uniformity in root canal filling points remains a controversial problem among endodontists¹⁷. This study showed that polypropylene points were not affected by autoclaving in terms of dimensional accuracy, and that they completely satisfied ISO requirements as to dimensional range limits. These results suggest that polypropylene points may be able to withstand autoclaving, and therefore be of an acceptable quality for use in the standardized techniques of root canal filling.

In this study, 10 cycles of conventional autoclaving produced only a slight decrease in flexural rigidity in the smaller sizes of polypropylene points, and no signs of fracture in the brittleness test. The reasons for the reduction in rigidity that was observed are as yet unknown. This may have been due to heat-generated deterioration of the polypropylene over 10 cycles of conventional autoclaving. Friedman *et al.*⁷ noted that root canal filling material should possess the proper combination of flexibility and rigidity to permit the negotiation of almost any root canal. Dummer⁴ noted that gutta-percha points had a disadvantage, as they lacked rigidity. Sato *et al.*²¹ reported that polypropylene points per-

Table 3 Fracture frequency of points in brittleness test in accordance with ISO 6877 requirements

	Polypropylene points	
	Non-treated	Autoclaving
030	0/5	0/5
050	0/5	0/5
070	0/5	0/5

formed better than gutta-percha points in reaching and closely fitting the apical seats of curved root canals, and speculated that this might be because of their high flexibility. How the reduction in flexural rigidity in the autoclaved polypropylene points observed in this study would affect their performance in root canal filling remains to be determined. Further experiments on the mechanical properties of polypropylene points should include tests on flexibility, yield strength, elongation, and resilience in order to ascertain their suitability for use in root canal procedures.

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