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Use of NiTi Rotary PathFile™ to create the glide path: comparison with manual preflaring in simulated root canals.

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Abstract

study compared changes to canal curvature and incidence of canal aberrations after preflaring with hand k-files or with NiTi rotary PathFile™ in S shape Endo Training Blocks. The influence of the operator's expertise was also investigated.

One hundred training blocks were colored with ink and pre-instrumentation images were acquired digitally. Preflaring was performed by an endodontist with PathFile™ (group 1) and hand K-files #10-15-20 (group 2); an inexpert clinician performed preflaring with PathFile™ (group 3) and hand K-files (group 4). Pre- and post-instrumentation images were superimposed to evaluate the outcomes investigated. Differences in canal curvature modification and incidence of canal aberration were analyzed respectively with the Kruskall-Wallis plus post-hoc tests, and by the Monte Carlo method ($p<0.05$).

The PathFile™ groups demonstrated significantly less modification of curvature ($p<0.001$) and fewer canal aberrations ($p<0.001$). No expertise-related difference was found within instrument groups ($p>0.05$), whereas the inexpert clinician produced more conservative shaping with Pathfiles than did the expert with manual preflaring ($p<0.01$).

Key words: Nickel-titanium, PathFile, rotary instruments, hand instruments, preflaring

Nickel titanium (NiTi) rotary instruments were introduced to improve root canal preparation. However, in clinical practice these instruments carry a risk of fracture, mainly due to flexural (fatigue fracture) and torsional (shear failure) stresses (1-3). Canal curvature is suspected to be the predominant risk factor for instrument failure due to flexural stresses (4-7); these stresses are not significantly influenced by the clinician. Shear failure may result from torsional stresses exceeding the elastic limit of the alloy, producing plastic deformation and, ultimately, fracture (3). Both the clinician and the instrumentation technique utilized may play significant roles in preventing torsional stresses, which may increase dramatically due to excessive pressure on the handpiece (8), a wide area of contact between the canal walls and the cutting edge of the instrument (9-10), or if the canal section is smaller than the dimension of the non-active or non-cutting tip of the instrument (9-10); the latter can cause what has been described as taper lock, especially with regularly tapered instruments (11). This risk may be reduced by performing coronal enlargement (12, 13) and manual preflaring, in order to create a glide path prior to using NiTi rotary instrumentation (14, 15). Thus the root canal diameter should be bigger than or at least the same size as the tip of the first rotary instrument utilized (14, 15). The new PathFile™ NiTi Rotary instruments for mechanical preflaring were recently introduced by Dentsply Maillefer (Fig.1). The system consists of three instruments, with 21-25-31 mm length and 0.02 taper; they have square cross-section. The PathFile™ #1 (purple) has a ISO 13 tip size; the PathFile™ #2 (white) has a ISO 16 tip size; the PathFile™ #3 (yellow) has a ISO 19 tip size. The manufacturer suggests using the first PathFile™ immediately after a #10 hand k-file has been used to scout the root canal to full working length.

The purpose of this study was to consider the maintenance of canal anatomy and the incidence of canal aberrations (apical zip and elbows) when comparing outcomes from manual (k-files) and mechanical preflaring (PathFile™). The impact of the clinician's expertise on the above outcomes was also evaluated.

Materials and Methods

One hundred ISO 15, 0.02 taper, S-shaped Endo Training Blocks (Dentsply Maillefer, Ballaigues, Switzerland) were utilized. Each simulated canal was colored with ink injected with a syringe. Four landmarks were placed in each block. Each specimens was mounted on a stable support consisting of a rectangular slot of the size of the specimen (30 X 10 mm) and a support for a digital camera (Nikon D70, Tokyo, Japan), positioned centrally and at 90° to the specimen. Digital images of all specimens before instrumentation were obtained and saved as TIFF format files. Specimens were then randomly assigned to four different groups (n=25) using a random numbers table.

In Group 1 (mechanical preflaring – expert clinician) a #10 stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) scouted the canal up to working length. Mechanical preflaring with new PathFile™ Rotary instruments 1, 2 and 3 (Dentsply Maillefer, Ballaigues, Switzerland) at working length was performed by an endodontist using an endodontic engine (X-Smart, Dentsply Maillefer, Ballaigues, Switzerland) with a 16:1 contra angle, at the suggested setting (300 rpm on display, 5 Ncm).

In Group 2 (manual preflaring – expert clinician) manual preflaring with new stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) #08-10-15-20 (Dentsply Maillefer, Ballaigues, Switzerland) was performed by an endodontist at working length.

In Group 3 (mechanical preflaring – inexpert clinician) the same procedure as group 1 was performed by an inexpert clinician.

In Group 4 (manual preflaring – inexpert clinician) the same procedure as group 2 was performed by an inexpert clinician.

After instrumentation all specimens in each group were repositioned in the slot and photographed as described above.

The pre- and post-instrumentation images were utilized to evaluate the variation in apical and proximal radius of curvature caused by instrumentation: the software Rhino (ver. 4.0, McNeel, USA) and the following procedure were employed:

- identification of the mean axis of canal geometry,
- identification of the reference points corresponding to the initial and final points of the two main curvatures of the canal geometry (apical and proximal curvatures),
- evaluation of the apical and proximal radius of curvature through best fitting with circumferences of known radius.

The digital images of the specimens before and after manual or mechanical canal instrumentation were aligned by taking the specimen boundarie as reference. Then were magnified and cropped to evidence the canal geometry. The image of each canal was used to identify its mean axis: starting from the canal apex, 31 points were identified along the canal at 1 mm intervals, each point corresponding to the mid-point of the canal cross-section as visualized in the digital image (in yellow in fig. 2, right). These points were used as control points for a Bezier curve (16); the curve obtained was simplified (through smoothing) by reducing the number of control points to 10. Visual comparison between the canal geometry, the initial complex Bezier curve and the final simplified Bezier curve could reveal any errors in identification of the canal mean axis.

The Bezier curve approximating the mean axis of the canal was analyzed to evaluate the curvature, which was in general continuously variable along the axis (fig. 2, right). The point of curvature change (null curvature) was taken as the flexus in the passage between the apical and the proximal curvatures of the canal and, as a consequence, as one of the extremities to be taken into consideration for quantitative curvature evaluation.

The canal apex, the point of null curvature between the extremities, and the first proximal point of the canal having null curvature, were selected for each canal in order to quantitatively evaluate the mean apical and proximal curvature by best-fitting with circumferences having different radii (fig. 2, left).

The apical and proximal radii of curvature after canal instrumentation were compared with those defining the canal shape before instrumentation. The curvature variation was evaluated as percentage variation: the smaller the percentage variation the less canal shape modification had been caused by instrumentation.

The pre-instrumentation digital images were superimposed over the post-instrumentation images, taking the landmarks as reference points and using digital imaging software (Adobe Photoshop, Adobe Systems Inc. USA). These paired images were utilized for the qualitative analysis of the incidence of aberrations made by three blind examiners, as described by Thompson & Dummer (17).

The Kolmogorov-Smirnov test for normality revealed a non-normal data distribution of curvatures. Differences among groups were thus analyzed using the non-parametric Kruskall-Wallis test and the Mann-Whitney post-hoc multiple comparisons U test. Differences were considered statistically significant when $p<0.05$.

The number of aberrations was estimated by cross-tabulation analysis and chi-square test using the Monte Carlo methods, which provide accurate results when the data fail to meet any of the underlying assumptions required for reliable results with the standard asymptotic method. Differences were considered statistically significant when $p<0.05$. All statistical analyses were performed using the SPSS for Windows 12.0 software package (SPSS, Inc. Chicago, IL).

Results

Modification of curvature

Descriptive statistics of the pre- and post- instrumentation radii of curvature (coronal and apical) and their percentage variation are summarized in table 1. The inferential analysis revealed statistically-significant differences among groups ($H=61,12$; $df=3$; $p<0.001$); the PathFile™ groups (1 and 3) showed a significantly lower percentage variation in coronal and in apical radius of curvature compared to the k-file groups (2 and 4) ($p<0.001$). Thus manual preflaring with k-files produced a more marked straightening of the coronal and apical curves with a significant modification of the original canal anatomy.

he clinician's expertise (endodontist versus inexpert clinician) did not appear to have a significant impact on the change in post-instrumentation curvature (group 1 vs 3; group 2 vs 4) (H=5,36; df=3; p=0.15). However, the less expert clinician appeared to be more prone to straightening the canal with manual preflaring than did the endodontist, although the difference was not statistically significant. It is also interesting to note that Group 3 (inexpert- PathFile™) showed less curvature straightening, with less change produced in the post-instrumentation coronal and apical radii of curvature, than did group 2 (expert- k-files) (p<0.01). This result suggests that, under the current experimental conditions, even a novice using the new NiTi rotary PathFile™ (group 3) may produce more conservative shaping than an expert endodontist can with manual preflaring (group 2).

Canal aberrations

The oObservation of canal aberrations showed a higher incidence of apical zips in the manual preflaring groups (Group 2=12; group 4=14) compared to the groups employing mechanical preflaring with PathFile™ (Group 1=1; group 3=1), the difference being statistically significant (p<0.001). In five specimens in which manual preflaring had been performed by the inexpert operator (Group 4) elbows were visible; however, the difference versus the other groups was at the limit of statistical significance (p=0.03).

Discussion

In the present study sSimulated canals were employed in this study to standardize experimental conditions. The S-shape canal utilized, possibly due to the increased difficulty of instrumentation, has been reported to be of use in pointing up differences in performance of instruments (18-19).

Furthermore, analysis of modifications in canal curvature after instrumentation has been widely used to evaluate the tendency of a technique, or of the mechanical properties of an instrument, to maintain the original canal anatomy or to straighten the curves (20) as well as to evaluate the performances of operators with different levels of expertise (21).

In this The first stage of the study comprised a quantitative analysis through observation of changes between pre- and post-instrumentation curvature, followed by a qualitative observation of any canal aberrations. The experimental method utilized appeared to be reliable in representing changes in canal curvature and for extrapolating the results. The new NiTi Rotary PathFile™ produced significantly less modification in coronal and apical canal curvature and fewer canal aberrations compared to manual preflaring with stainless-steel k-files. Therefore, under the study conditions, it may be assumed that these instruments better respect the original canal anatomy, as shown in fig.3. No macroscopic deformations or fractures of any instrument, mechanical or manual, occurred during the experiment.

It has been demonstrated that cCoronal enlargement (12, 13) and preliminary manual preflaring to create a glide path have been shown to be fundamental for safer use of NiTi rotary instrumentation (14, 15). Canal scouting and preflaring are the first phases of canal instrumentation, during which procedural difficulties or errors may more frequently occur (22). NiTi Rotary PathFile™ were recently introduced by Dentsply Maillefer for mechanical preflaring. It is suggested that these instruments are used after a #10 k-file has scouted the canal. It may be hypothesized that the use of a small size hand k-file followed by more flexible and less tapered NiTi Rotary PathFile™ could provide advantages in the form of a less invasive and safer approach to the subsequent canal instrumentation with any NiTi Rotary system, but this still needs to be investigated.

The clinician's expertise did not appear to have a significant impact on the outcomes investigated, in groups employing the same instrument. Both endodontist and inexpert clinician produced similar results when using PathFile™, whereas the difference in expertise is generally evident when using NiTi Rotary instruments (23-26). However, in this study. the less expert clinician was found to have an increased tendency to straighten the canal and a higher incidence of canal aberrations such as apical zips and elbows when employing manual preflaring with stainless steel k-files. Canal aberrations are usually due to procedural errors, and may be linked to inadequate shaping and poor quality of the obturation seal (22); they negatively affect the long-term success of root canal therapy (22).

On the other hand, it is interesting to note that inexpert clinicians could benefit from mechanical preflaring with PathFile™, since in this study they obtained better results than those offered by manual preflaring performed by experts. This result suggests that the PathFile™ NiTi rotary system is less technique-sensitive, and that even the inexpert clinician may feel confident when using it in the conditions of this study.

In conclusion, within the limits of this study, NiTi Rotary PathFile™ appear to be suitable instruments for safe and easy creation of the glide path prior to use NiTi Rotary shaping of the canal. PathFile™ demonstrate better maintenance of the original canal anatomy with less modification of canal curvature and fewer canal aberrations compared to manual preflaring performed with stainless steel k-files; the performance of the inexpert clinician provided a similar outcome to that of the expert using PathFile™ for mechanical preflaring.

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Figure legends

TABLE 1. Coronal and apical curvature: descriptive statistics of the radii of curvature (mm) and the variation (%) after preflaring.

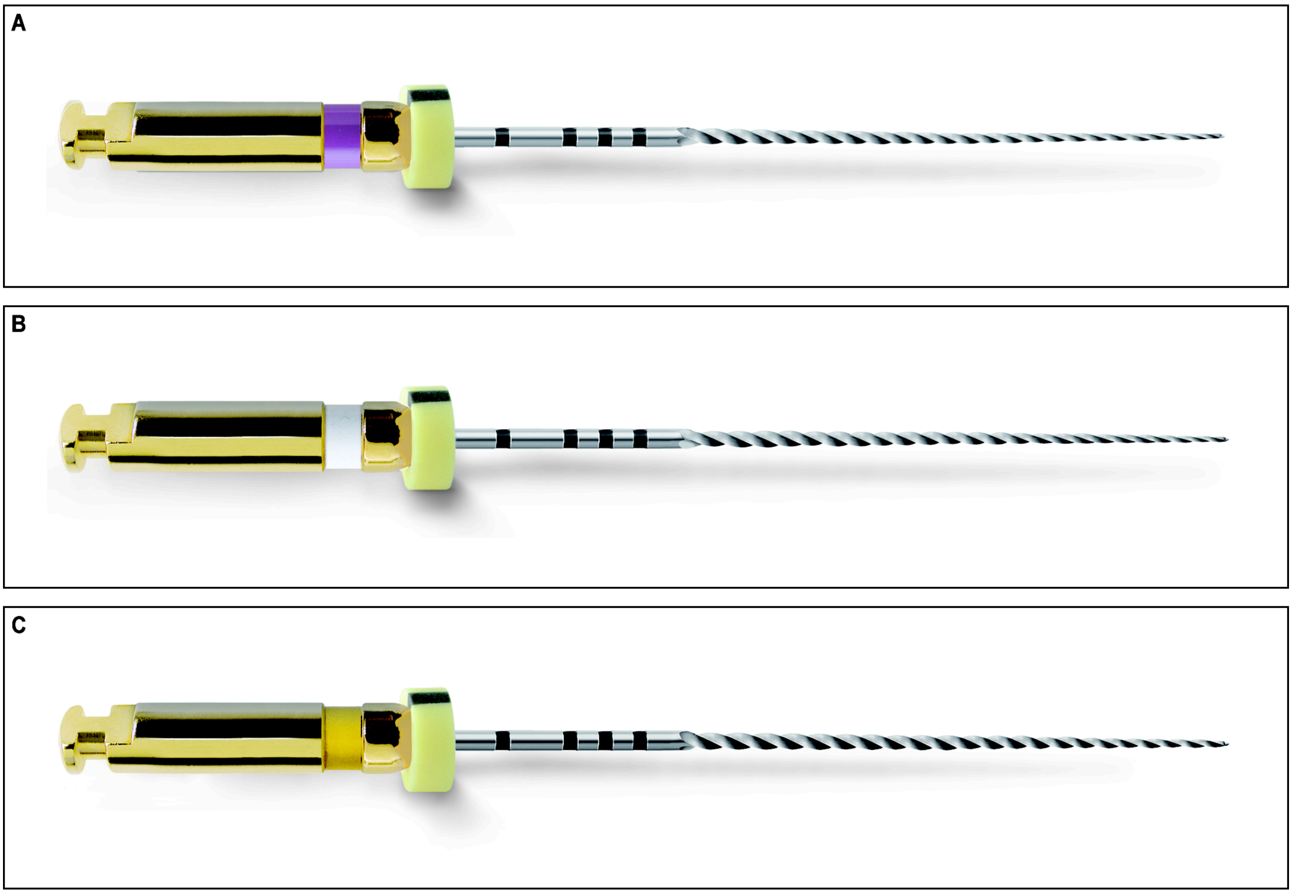
Figure 1. PathFile™ NiTi Rotary instruments. A) no. 1, ISO 13 tip; B) no. 2, ISO 16 tip; C) no.3, ISO 19 tip.

Figure 2. Left: determination of the mean radius of curvature by means of the best-fit circumference. Right: detail of the point-by-point construction of the mean axis of the canal (yellow). Qualitative evaluation of the curvature along the canal axis and determination of end-points to determine the radius of curvature (orange).

Figure 3. Superimposition of pre- and post-instrumentation images. A) group 1 PathFile™/expert; B) group 2 K-files/expert; C) group 3 PathFile™/inexpert; D) group 4 K-files/inexpert.

Group	1 PathFile™/expert			2 Kfiles/expert			3 PathFile™/inexpert			4 Kfiles/inexpert		
Coronal	**pre**	**post**	**%var**	**pre**	**post**	**%var**	**pre**	**post**	**%var**	**pre**	**post**	**%var**
Mean	49.43	53.51	8	50.22	63.48	27	49.58	52.36	6	51.83	68.62	33
STD	3.70	3.52	6	2.76	6.90	13	3.02	4.33	7	4.47	7.02	13
Median	49.70	52.30	6	50.50	64.30	25	49.10	51.40	4	51.20	66.40	30
Minimum	43.1	48.5	1	45.0	50.4	2	44.8	47.1	0	44.5	56.4	9
Maximum	56.9	61.7	22	55.5	78.9	65	55.8	68.2	33	66.0	83.0	57
95% C.I.	47.98	52.13	5.65	49.14	60.78	21.90	48.40	50.66	3.26	50.08	65.87	27.90
	50.88	54.89	10.35	51.30	66.18	32.10	50.76	54.06	8.74	53.58	71.37	38.10
Apical	**pre**	**post**	**%var**	**pre**	**post**	**%var**	**pre**	**post**	**%var**	**pre**	**post**	**%var**
Mean	44.58	53.33	20	44.66	56.82	27	44.61	54.49	17	48.40	66.96	38
STD	5.93	7.88	14	3.95	10.59	21	3.16	4.50	10	4.77	19.49	37
Median	43.20	54.40	16	44.80	53.60	21	46.20	53.40	17	47.80	60.30	24
Minimum	24.9	26.3	1	36.7	42.3	2	42.1	46.9	11	40.2	47.9	2
Maximum	54.3	68.6	61	52.7	92.3	102	53.4	62.8	23	57.2	128.1	144
95% C.I.	42.26	50.24	14.51	43.11	52.67	18.77	43.37	52.73	13.08	46.53	59.32	23.50
	46.90	56.42	25.49	46.21	60.97	35.23	45.85	56.25	20.92	50.27	74.60	52.50

TABLE 1. Coronal and apical curves: descriptive statistics of the radii of curvature (mm) and their variation (%) after preflaring.



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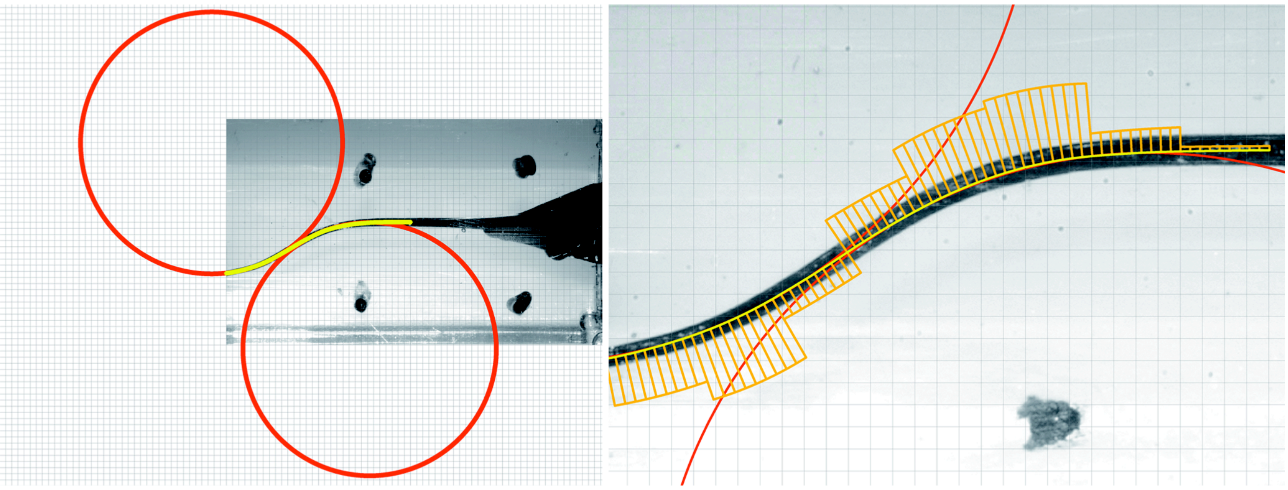
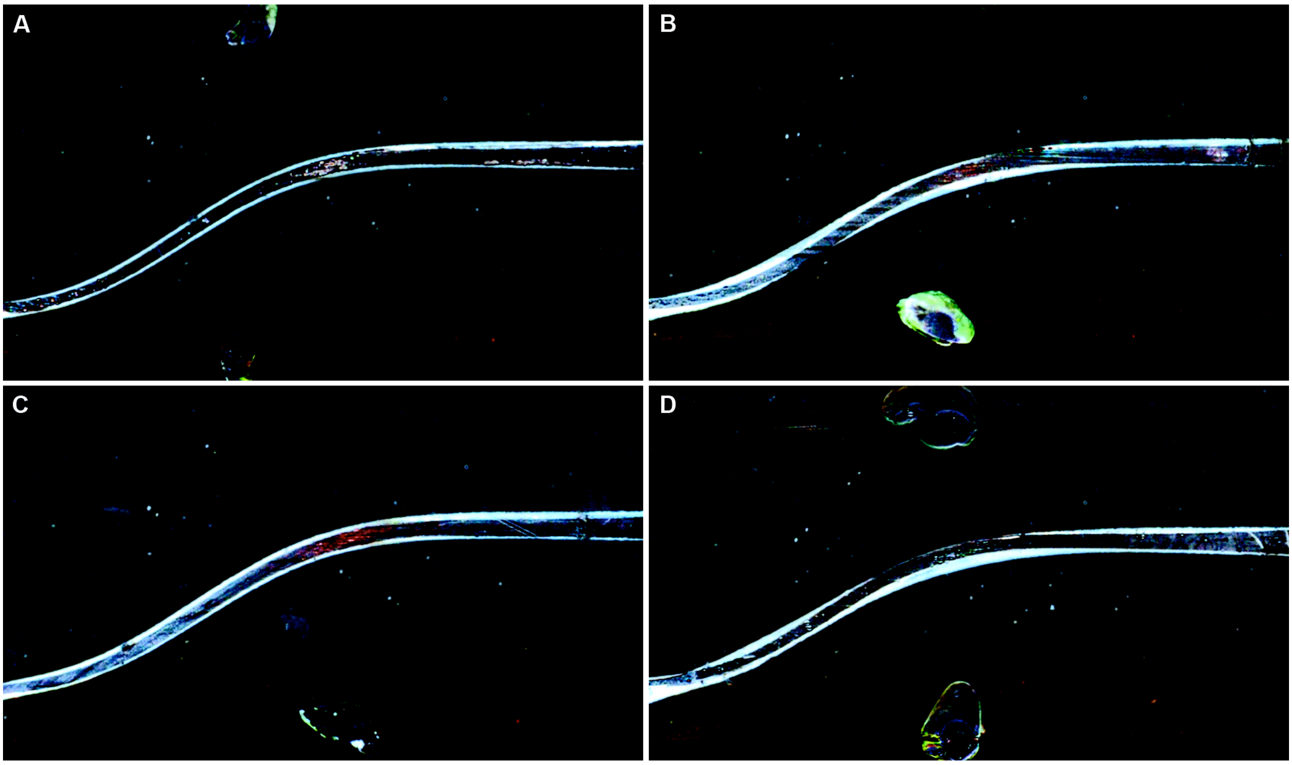


Figure 2. Left: determination of the mean radius of curvature by means of the best-fit circumference. Right: detail of the point-by-point construction of the mean axis of the canal (yellow). Qualitative evaluation of the curvature along the canal axis and determination of end-points to determine the radius of curvature (orange).



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