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GEOMETRIC AND ELECTRON-MICROSCOPIC EVALUATION OF IMPROVED CONDITIONING FOR INTRAORAL OPTICAL IMPRESSIONS

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Objectives:

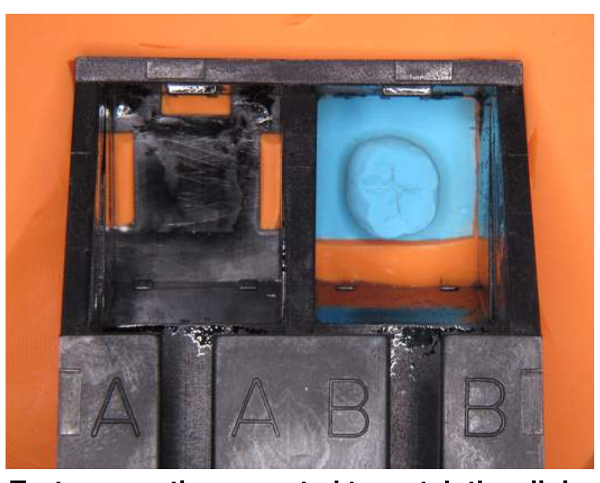
Intraoral optical impressions require surface coatings of the scanning field. After positive biocompatibility testing, a Laponite®-based formulation was compared with commercially available matting agents.
It was, therefore, the aim (i) to assess dimensional accuracy, (ii) clinical handling, and (iii) to compare the metric outcome of three standardized tooth preparations for ceramic restorations.

Materials and Methods:

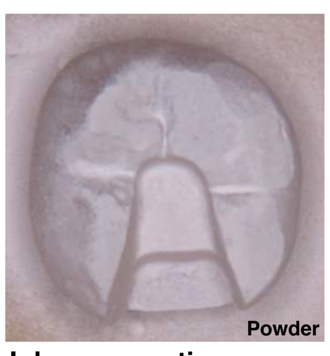
Three extracted human molars were prepared for inlay, overlay and partial crown and mounted to match the clinical setting of a CEREC Bluecam® scanner (SIRONA, Bensheim, Germany). A calibrated operator conditioned test preparations with the coating agents Cerec Powder® (VITA, Bad Säckingen, Germany), Optispray® (SIRONA) and the experimental Laponite® formulation applied by pump-spray aerosol and consecutive air drying. These standardized restorative molar preparations were scanned, resulting in 50 digital models per tooth and per coating agent. Measurements of model dimensions, representing the outlines of restorations, were carried out with CEREC® software 4.2 (SIRONA). Quality characteristics (model surfaces, preparation margins, model artifacts) were assessed by descriptive index scores (1 to 3) and statistically analyzed (U-test, $p<0.05$). Micromorphology of conditioned tooth surfaces as well as dental restorative materials was evaluated by scanning electron microscopy (SEM).

Experimental setup:

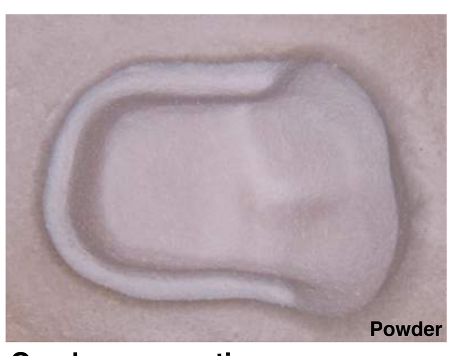
CEREC AC® unit with Bluecam® Scanner



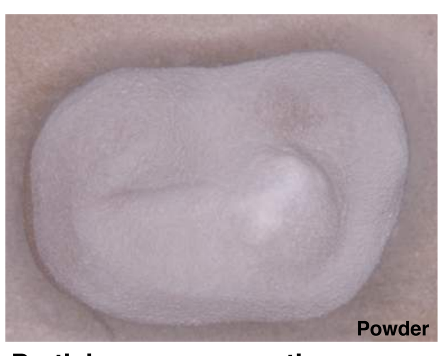
Test preparation mounted to match the clinical setting for standardized scanning with Bluecam®



Inlay preparation

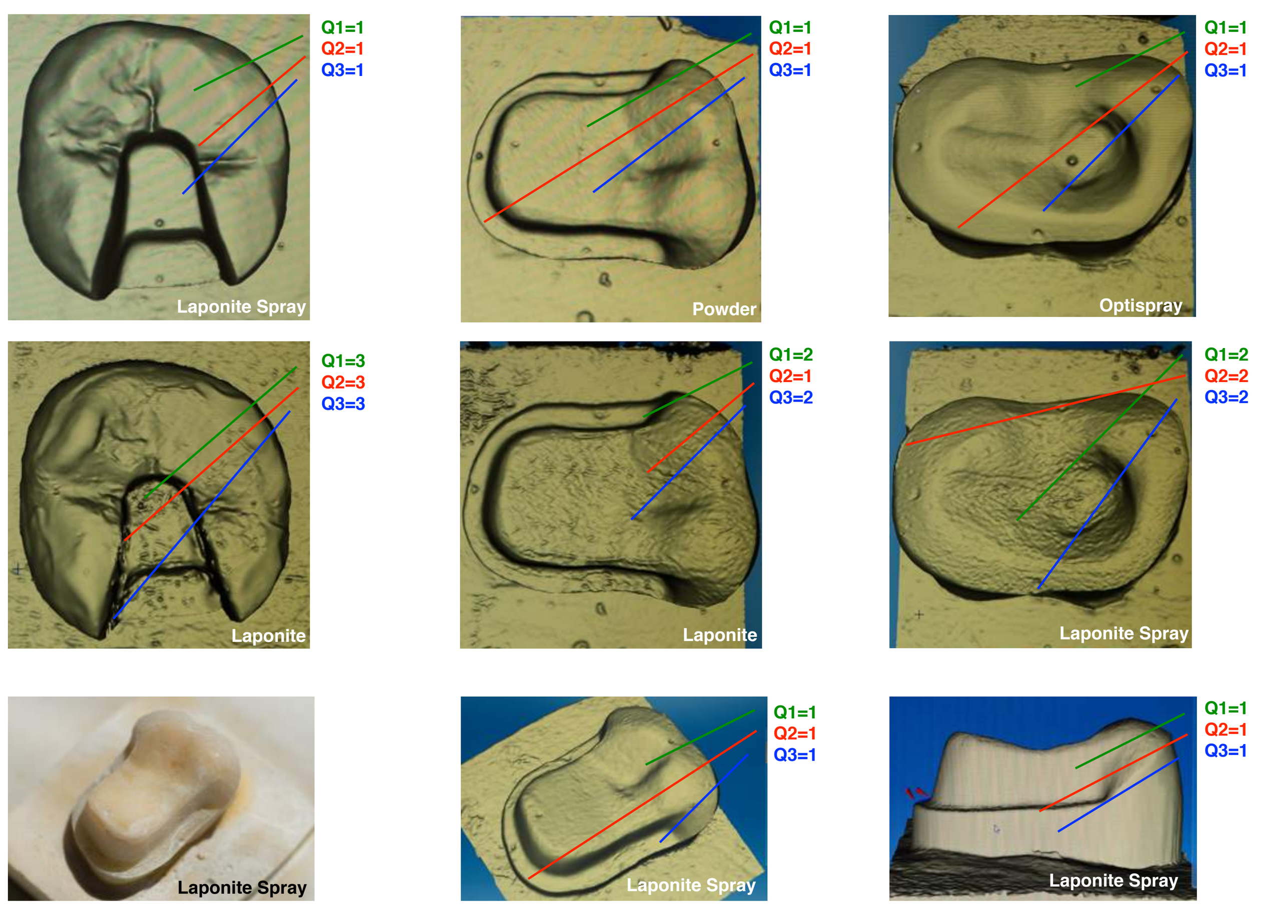


Overlay preparation



Partial crown preparation

Descriptive index:



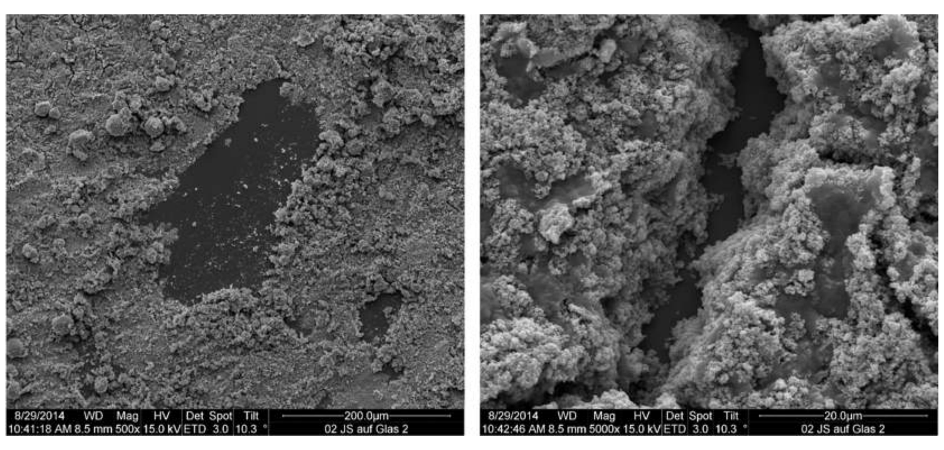
Quality characteristics of the digital models were assessed by descriptive index scores

Q1 = model roughness (1-3) Q2 = clarity of preparation margins (1-3) Q3 = occurrence of artifacts (1-3)

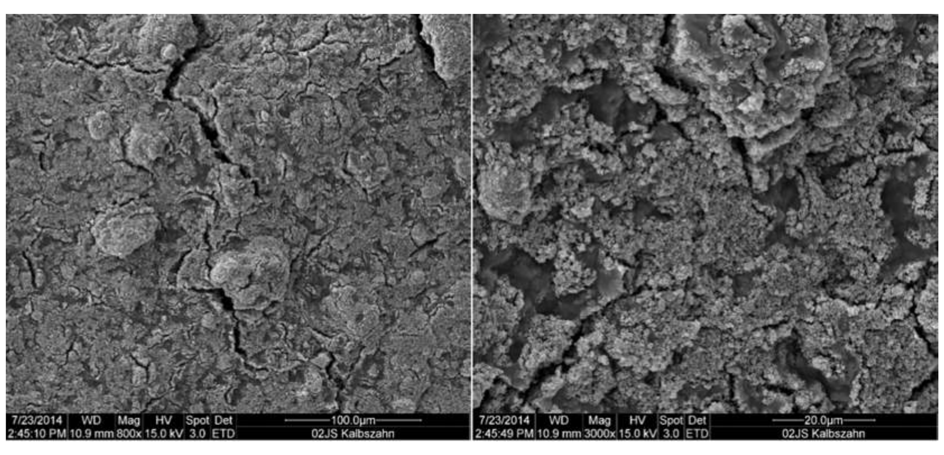
Results:

All methods of surface conditioning resulted in optical impressions and consecutive tooth models which reproduced the correct anatomical situation. There were no statistical differences in any of the standardized metrical model dimensions. However, concerning the scoring of surface roughness, reproduction of preparation margins and model artifacts, there was no significantly better formulation than the Laponite® coating except for the clarity of margin representation of the partial crown preparation. Scanning electron micrographs showed densely coated dental tissues. Dental restorative materials like gold alloys, amalgam, composite, and acrylates were also well coated. Micromorphologically no significant surface differences of the coating layers were detected.

SEM Analysis:

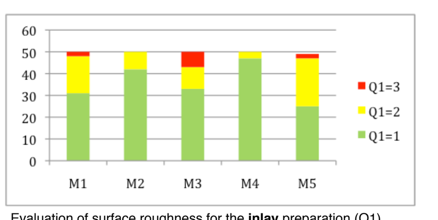


SEM view on Laponite Spray coating on glass surface after drying at room temperature, transfer on SEM-slides and sputtering (2 min.).
Laponite Spray film is characterized by dense coatings of TiO_2 particles remaining on the surface after evaporation of the liquid components of the Laponite-TiO_2 emulsion.
Scatteredly small defects, agglomerations and fissures in the coating films were detected.
Average layer thickness of Laponite coatings on different surfaces was observed at approximately 20 µm.



Micromorphology of this Laponite film observed on a bovine tooth represents a homogeneous coating of the tooth surface with TiO_2 pigment due to the adequate adhesion properties of the Laponite-TiO_2 emulsion on various dental and common restorative surfaces.
Small fissures and minor agglomerations in the coating film occurred as a result of the drying process.
The formation of nano-crystalline TiO_2 molecules and the inorganic components of the Laponite Spray covered the conditioned tooth surface completely.

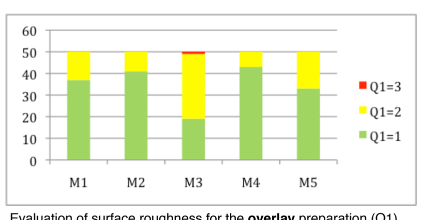
Statistical Analysis:



Evaluation of surface roughness for the **inlay** preparation (Q1)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the inlay preparation with Laponite Spray resulted in significantly better model surface quality than conditioning with Powder or Laponite.
There is no significant difference between Laponite Spray and Optispray.

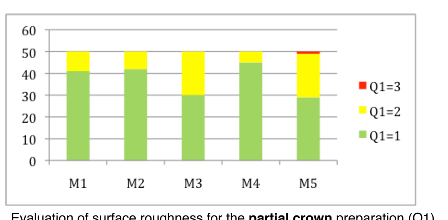
M4 vs. M1: **U=2,77 (p<0,01) /** M3 vs. M4: **U=2,48 (p=0,013)**
n=50



Evaluation of surface roughness for the **overlay** preparation (Q1)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the overlay preparation with Laponite resulted in significantly inferior model surface quality compared with the other conditioning agents.
There is no significant difference between the other tested conditioning agents.

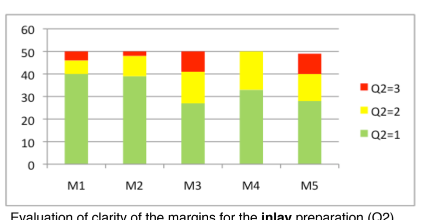
M3 vs. M2 **U=3,82 (p<0,01) /** M3 vs. M4 **U=4,16 (p<0,01)**
n=50



Evaluation of surface roughness for the **partial crown** preparation (Q1)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the partial crown preparation with Laponite Spray and Optispray resulted in significantly better model surface quality than conditioning with Laponite or Laponite II.

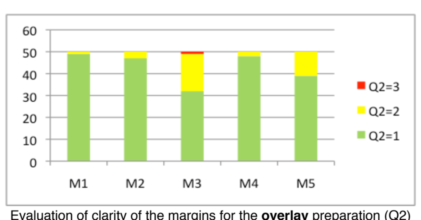
M4 vs. M3 **U=2,58 (p<0,01) /** M2 vs. M3 **U=2,06 (p=0,039)**
n=50



Evaluation of clarity of the margins for the **inlay** preparation (Q2)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the inlay preparation with Powder and Optispray resulted in significantly better preparation margin quality than conditioning with Laponite.
There is no significant difference between Laponite Spray compared with any other conditioning agent.

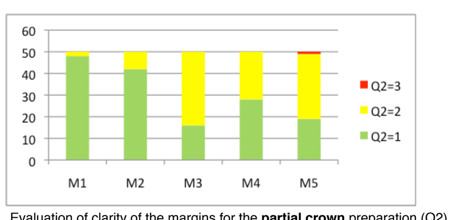
M1 vs. M3: **U=2,23 (p<0,026) /** M2 vs. M3: **U=2,25 (p=0,025)**
n=50



Evaluation of clarity of the margins for the **overlay** preparation (Q2)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the overlay preparation with Laponite resulted in significantly inferior preparation margin quality on the digital models compared with the other tested conditioning agents.

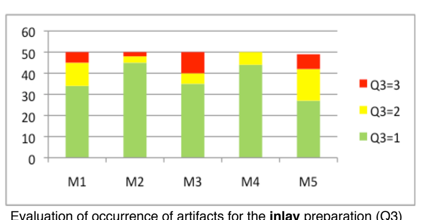
M3 vs. M1 **U=2,92 (p<0,01) /** M3 vs. M4 **U=2,76 (p<0,01)**
n=50



Evaluation of clarity of the margins for the **partial crown** preparation (Q2)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the partial crown preparation with Powder and Optispray resulted in significantly better preparation margins on the digital models than surface conditioning with the other tested conditioning agents.

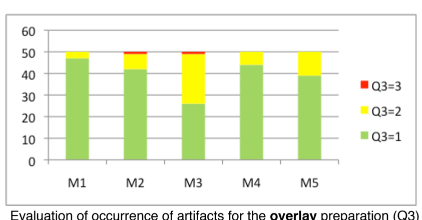
M1 vs. M4 **U=3,44 (p<0,01) /** M2 vs. M4 **U=2,41 (p=0,016)**
n=50



Evaluation of occurrence of artifacts for the **inlay** preparation (Q3)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the inlay preparation with Laponite II resulted in significantly more artifacts on the digital models than conditioning with Optispray or Laponite Spray.
All other conditioning agents do not show any significant differences compared with each other.

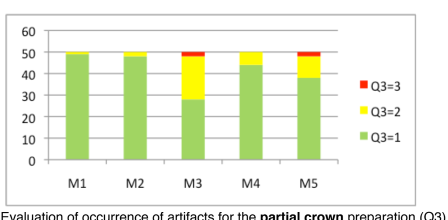
M5 vs. M2: **U=2,96 (p<0,01)** / M5 vs. M4: **U=2,96 (p=<0,01)**
n=49



Evaluation of occurrence of artifacts for the **overlay** preparation (Q3)

Bivariate Mann/Whitney-U-test of the median shows that conditioning the overlay preparation with Laponite resulted in comparison with all other tested conditioning agents in more artifacts on the digital models.
The differences between the other tested conditioning agents are insignificant.

M3 vs. M4 **U=3,12 (p<0,01) /** M3 vs. M1 **U=3,63 (p<0,01)**
n=50



Evaluation of occurrence of artifacts for the **partial crown** preparation (Q3)

Bivariate Mann/Whitney-U-test of the median shows that regarding the occurrence of artifacts on the digital models of the partial crown preparation conditioning with Laponite resulted in significantly more artifacts on the digital models than tooth conditioning with the other tested agents.
The differences between the other tested conditioning agents do not expose any significant differences.

M3 vs. M2 **U=3,46 (p<0,01) /** M3 vs. M4 **U=2,80 (p<0,01)**
n=50

M1 = Powder   M2 = Optispray   M3 = Laponite   M4 = Laponite Spray   M5 = Laponite II
Q1 = model roughness (1-3) Q2 = clarity of preparation margins (1-3) Q3 = occurrence of artifacts (1-3)

Conclusions:

Thixotropy and adhesion properties of the Laponite®-based scanning liquid may simplify the clinical application and improve the morphological reproducibility of coating agents for intraoral scanning procedures.

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