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Biomaterials Research Report
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Capsule Waste Evaluation for Restorative Materials

Introduction:

As anthropogenic global climate warming races on, environmentally conscious manufacturers seek ways to reduce the Global Warming Potential (GWP) in the production of the materials necessary for dental procedures. A recent study that examined the environmental impacts of dental restoratives found that over 95% of the GWP in terms of kg CO2 produced for glass ionomer cements (GIC) was largely accounted for in the process for creating the packaging for the restoratives[1]. It also found that GIC had the smallest overall GWP between the categories of amalgam, resin-based composites and resin-based adhesives highlighting the sustainability of this class of restorative materials.

Given the urgent nature of the challenges facing the planet, this study focused on the sustainability of the dental packaging design of capsule-based restoratives which are mixed using a triturator. We also examined the amount of usable restorative that can be applied from the capsule after mixing compared to what is originally packaged to give an idea of the efficiency of the packaging system. This study should highlight areas in which manufacturers can improve their packaging designs for a more sustainable dental industry.

MATERIALS:

EQUIA Forte HT Fil A2 (GC America), ***Ketac Universal Aplicap A2*** (3M), ***Surefil one A2*** (Dentsply Sirona), ***Cention Forte A2*** (Ivoclar), ***RIVA Self-Cure HV A2*** (SDI)

Test Methods:

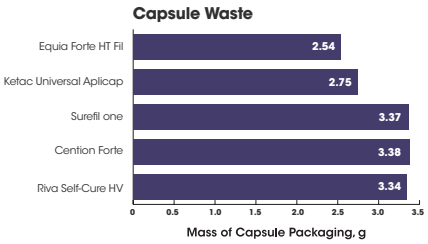
Capsule Packaging Content Measurement (n=5): Capsules were weighed in the initial condition before being sectioned with a slow-speed diamond wafering saw and thoroughly cleaned of material (powder and liquid) by rinsing with water and application of a brush, and multiple rinses with ethanol before drying with an air syringe and placed in a 40°C oven to dry for at least 30 minutes before mass measurement. Additional measurement and sectioning of cleaned specimens was conducted to determine the amount of packaging material lost in the sectioning process and the average value was added to the measurements of the packaging content values.

Useable Restorative Material Application Measurement (n=5): Capsules were weighed in the initial condition using a calibrated analytical scale (Fisher Scientific accuSeries 224), and material was fully applied according to manufacturer instructions and the extruded cement was weighed to determine the mass of material that can be applied per capsule.

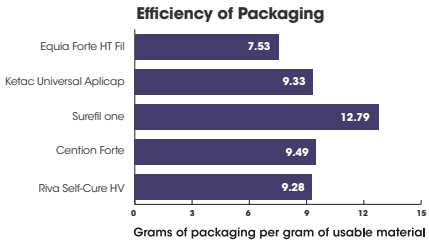
Total Restorative Material Measurement (n=5): The difference in the initial capsule mass and the mass of the capsule packing content determined the value for how much total restorative material was initially contained in each capsule.

Wasted Restorative Material Measurement (n=5): The difference in the calculated Total Restorative Material contained in each capsule was subtracted from the mass of the average extruded or Useable Restorative Material to determine how much restorative material is unused after full application, primarily inside the tip of the capsule.

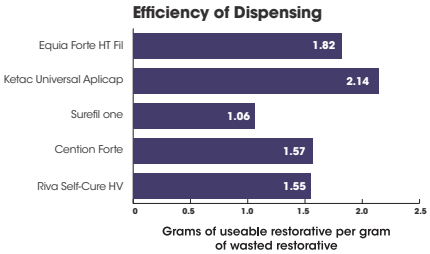
Results:



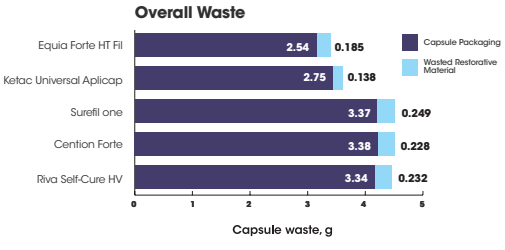
Equia Forte HT Fil has the least plastic waste in the package of the tested capsules. This was identified as the single most important factor for global warming impact.



In a comparison of the ratio of packaging waste to how much material is applied, ***Equia Forte HT Fil*** has the most efficient packaging, which has only 7.5 grams of packaging for every gram of restorative material.



While ***3M Ketac Universal Aplicap*** has the highest ratio of usable restorative compared to wasted restorative, it also applies the 2nd lowest amount of restorative at 0.29g, with ***Surefil one*** applying 0.26g, and ***Equia Forte HT Fil*** applying 0.34g.



While, the global warming impact study indicated that the packaging waste was the greatest concern, this shows the relatively low amount of wasted restorative material in proportion to the capsule packaging waste.

Conclusion:

Equia Forte HT Fil capsule packaging has less total mass than the other products tested while wasting the least amount of packaging per gram of usable restorative, making it the most efficient packaging design.

REFERENCES:

[1] *Smith L, Ali M, Agrissais M, Mulligan S, Koh L, Martin N. A comparative life cycle assessment of dental restorative materials. Dent Mater. 2023;39(1):13-24. doi:10.1016/j.dental.2022.11.007*

