

Mechanical properties of RALLY high viscosity and medium viscosity polymethylmethacrylate (PMMA) bone cements

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Introduction

Acrylic bone cements have been used in surgery since 1958 when Sir John Charnley first used a cement to anchor a femoral head prosthesis.¹ Since then polymethylmethacrylate (PMMA) bone cements have become the material of choice for adhering joint replacements to the patient's skeleton.

RALLY[®] High viscosity (HV) and RALLY Medium viscosity (MV) are new PMMA cements. Both cements are dyed green so the cements are easily distinguished from bone during implantation and clean-up or in the case of revision, see Figure 1. To demonstrate that these new bone cements are as strong as existing cements currently available, RALLY HV and RALLY MV mechanical properties were tested against cements that have been on the market for over 30 years, Palacos[™] R (Zimmer) and Simplex[™] P (Stryker).

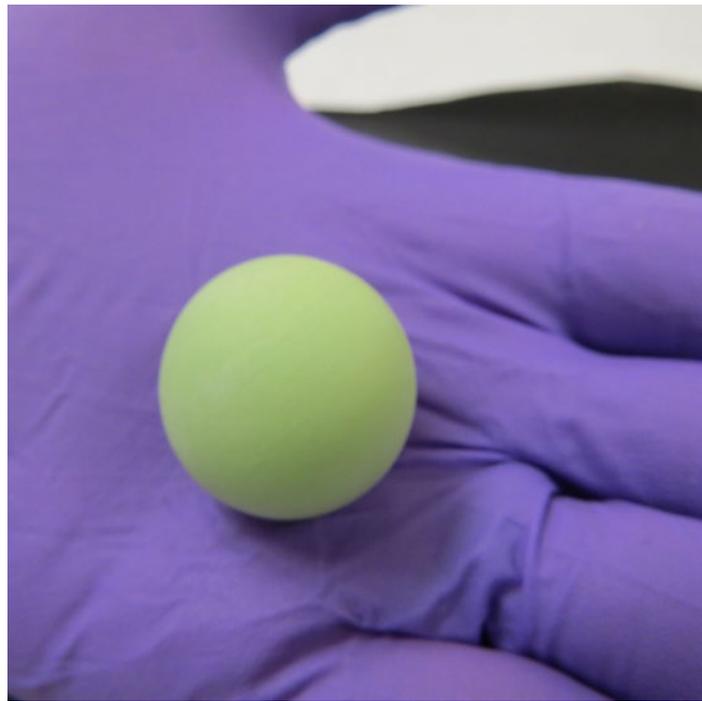


Figure 1: RALLY HV cement.

Materials and methods

To evaluate the mechanical performance of these new cements, testing was carried out with the following cements:²

- RALLY High viscosity (HV)
- RALLY Medium viscosity (MV)
- Simplex P (Stryker)
- Palacos R (Zimmer)

Shear, compressive and fatigue strength of the cement samples were evaluated.

For making samples, the required box of cement was conditioned at 23°C for two hours before being mixed following the manufacturer's instructions. To represent the mechanical properties of cements used in the dough state, all cements were allowed to dough before being placed in a mold. All molds were placed in hydraulic press and sufficient pressure to close the molds applied. Samples were left to cure for approximately one hour in the mold before being removed and placed in the incubator for until 24 ± 2 hrs from the start of mixing, when they were removed for testing.

Flexural testing was carried out following the method described in ISO 5833.³ Briefly, samples were molded into rectangular bars 75mm long, 10mm wide and 3.3mm thick.

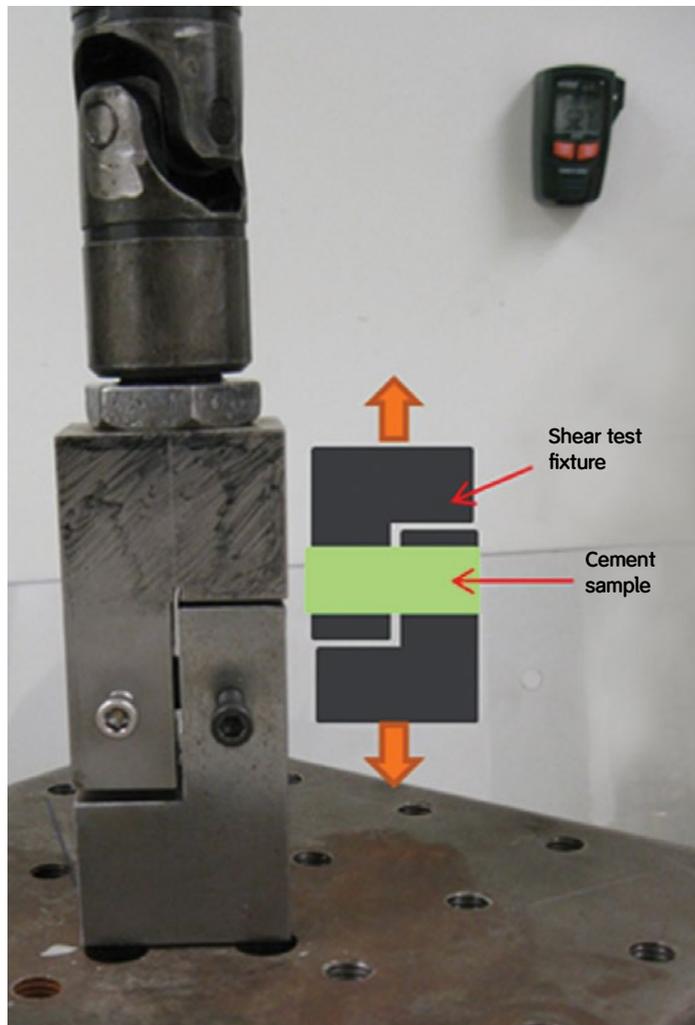


Figure 2: Photograph of the fixture used to measure the shear strength of the PMMA cements.

They were tested in 4 point bending using a support span of 60mm and a loading span of 20mm. A test speed of 5mm/min was used. The load – extension data was collected and the flexural strength and modulus were calculated from the data.

For evaluating the compressive strength, the cements were cast into cylinders 6mm in diameter and 12mm long using a PTFE mold. Samples were tested at 22mm/min and the compressive strength was calculated from the peak load.

The shear strength was measured in the single shear mode, see Figure 2. Samples were molded to cylindrical rods 12.7mm in diameter and 38.1mm long. Shear testing was conducted at a test speed of 2.54mm/min.

A one-way ANOVA was performed in MINITAB 16.2.2.0 Statistical software to investigate differences in performance between bone cements. Providing that a p value of <0.05 was obtained in the ANOVA table. Post hoc analysis was carried out using the Tukey procedure to compare each pair of cements. A p-value of <0.05 was considered sufficient evidence to conclude differences between cements.

Results and discussion

The results of the flexural testing are shown in Figures 3 and 4. All samples tested were above the minimum value of 50MPa for flexural strength and 1800 MPa for flexural modulus as specified in ISO 5833.

The results of the compression testing are shown in Figure 5. There was no statistical differences between any cements tested. The RALLY HV cement has a significantly higher compressive strength than the other cements.

The results of the shear testing are shown in Figure 6. There were no statistical differences between any cements tested.

As confirmation of this data, the properties measured for Simplex™ P and Palacos™ R are within the ranges reported by Lewis⁴ with a range of different mixing methods.

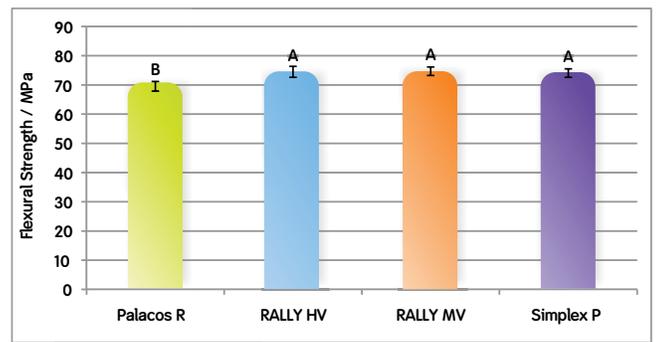


Figure 3: Flexural strength of the different PMMA cements. Bars that do not share a letter in the label are significantly different. Error bars are \pm one standard deviation.

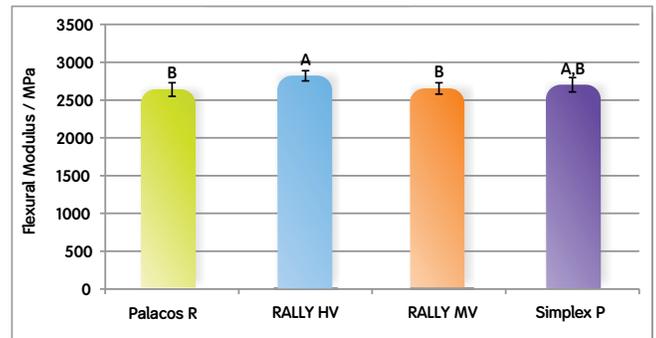


Figure 4: Flexural modulus of the different PMMA cements. Bars that do not share a letter in the label are significantly different. Error bars are \pm one standard deviation.

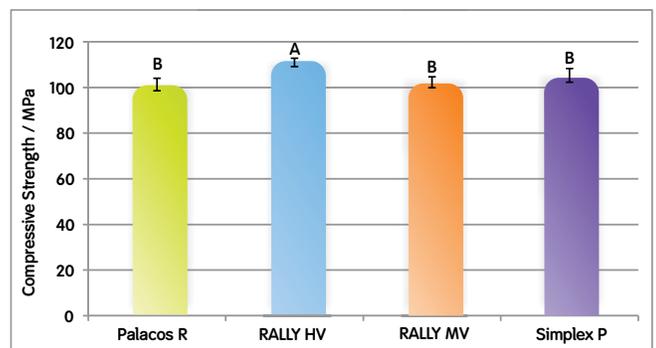


Figure 5: Compressive strength of the different PMMA cements. Bars that do not share a letter in the label are significantly different. Error bars are \pm one standard deviation.

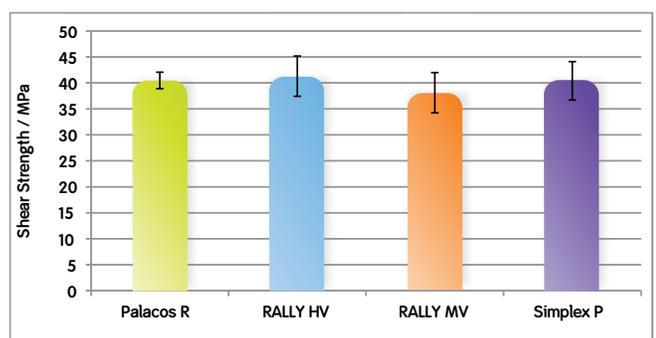


Figure 6: Shear strength of the different PMMA cements. There was no significant difference between cements. Error bars are \pm one standard deviation.

Conclusions

The shear, compressive and flexural properties of RALLY[®] High Viscosity (HV) and RALLY Medium Viscosity (MV) were compared to that of Simplex[™] P and Palacos[™] R.

All results were compared using an ANOVA test with post hoc analysis carried out using the Tukey procedure to compare each pair of cements. A p-value of <0.05 was considered sufficient evidence to conclude differences between cements. There was no significant difference between the cements for the shear strength. The compressive strength of RALLY HV was significantly higher than the other cements tested. For the flexural properties Palacos R had a significantly lower strength than all the cements and a modulus that was significantly lower than RALLY HV and Simplex P.

The RALLY HV and RALLY MV cements were equivalent or better than at least one of the competitor cements tested in this work for all of the properties measured.

References

1. Charnley, J., "Anchorage of the femoral head prosthesis of the shaft of the femur.", J Bone Joint Surgery, 1960; 42B, pp28-30.
2. Ref: Smith & Nephew OR-15-135.
3. ISO 5833:2002, "Implants for surgery – Acrylic Resin Cements".
4. Lewis, G., "Properties of Acrylic Bone Cement: State of the Art Review", J Biomed Mater Res (Applied Biomaterials), 38, pp155-182, 1997.

For detailed product information, including indications for use, contraindications, effects, precautions and warnings, please consult the product's Instructions for Use (IFU) prior to use.

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