WORKING CHARACTERISTICS OF RADIO-OPACIFIED BRUSHITE CEMENTS

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INTRODUCTION: X-Ray opacification of calcium phosphate hydraulic cements (CPHC) is a pre-requisite prior to use them safely in image-guided vertebroplasty. Theoretical calculations (1) have shown that injectable CPHC presently available on the market exhibit linear attenuation coefficients below 1.6 cm^{-1}, whereas the recommended value should be close to 2.5 cm^{-1} in order to achieve enough contrast between the injected cement and the surrounding tissues (2).

According to theoretical calculations, injectable CHPC of the Brushite family – i.e. based on mixtures of $Ca(H_2PO_4)_2•H_2O$ (MCPM) and β-$Ca_3(PO_4)_2$ (β-TCP) transformed into $CaHPO_4•2H_2O$ (Brushite, DCPD) upon consolidation – can be obtained with the requested radio-opacity by incorporating about 100 mg iodine per mL of freshly mixed cement.

This work investigates the effects of different iodine sources on the working characteristics of an injectable Brushite cement formulation containing plaster of Paris (CSH, $CaSO_4•2.H_2O$) as a setting regulator.

METHODS: The Brushite cements were made of 1.201 g β-TCP, 0.781 g MCPM, 0.339 g CSH and mixed with 1.080 mL of distilled water ; 0.09 g of di-sodium di-hydrogen pyrophosphate (NHPP) (Fluka) was added to the mixture in order to adjust the setting time at approximately 20 min.

Four different iodine compounds were tested : NaI, $NaIO_3$ (Merck, pro analysis) Iopentol® (Imagopaque from Nycomed Imaging AS) and Iopamidol® (Iopamiro from Bracco SpA). The two latter compounds are tri-iodinated benzoic molecules commonly used for angiographic diagnosis. In all cases, theamount of iodine-containing substance represented 100 mg of iodine per mL of fresh cement, so as to achieve a theoretical linear attenuation coefficient of 2.47 cm^{-1}. The radio-opacifiers were incorporated by dissolution in the mixing water ; given the low aqueous solubility of $NaIO_3$, only partial dissolution of the additive was achieved. The other ingredients were added in the following order : NHPP, MCPM, CSH, β-TCP ; thorough mixing was effected after each addition. A iodine-free cement was used as control.

The setting times of the cements were measured with the Vicat needle technique (neddle ø = 2 mm, weight 98.4 g). Their mechanial properties were tested on wet cylindrical specimens aged for 24 h at 37 °C and 100 % relative humidity in the uniaxial (ø x h. = 8.7 x 18 mm) and diametral (ø x h = 8.7 x 6 mm) compression modes at a loading rate of 0.3 mm/min ; each composition was tested 4 times.

RESULTS AND DISCUSSION:

Setting times. No significant differences were found between the iodine-containing cements and the control (ST = 24 ± 1 min).

Mechanical properties. The results are summarised in Fig. 1. In diametral compressive strength, cements containing NaI, Iopentol® and Iopamidol® perform better compared to the control and the $NaIO_3$–containing cements In uniaxial compressive strength, Iopentol®–containing cements are significantly better than those containing Iopamidol®, the latter performing the same as the control ; $NaIO_3$ and NaI–loaded cements are worse than the control.

CONCLUSIONS: Brushite cements can be opacified with various iodine–containing additives : NaI, $NaIO_3$ Iopentol® and Iopamidol®. None of these additives affects significantly the setting times of the cements. In general, they do not affect to a large extent the mechanical performances of the consolidated cements, even though NaI appears to improve significantly the diametral compressive strength (3.1 *vs* 2.1 ± 0.8 MPa), immediately followed by Iopentol® ; the latter also improves significantly the uniaxial compressive strength (14.5 *vs* 10.5 ± 2.5 MPa). Thus, from the viewpoint of the working properties, Iopentol® appears to be the first–choice radio-opacifying additive.

REFERENCES:

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ACKNOWLEDGEMENTS: This work has been granted by the Foundation of the "Hôpital Orthopédique de la Suisse Romande". Dr A. Uske

(Service de Radiologie, CHUV) is ackowledged for his help in collecting the radio-opacity data.

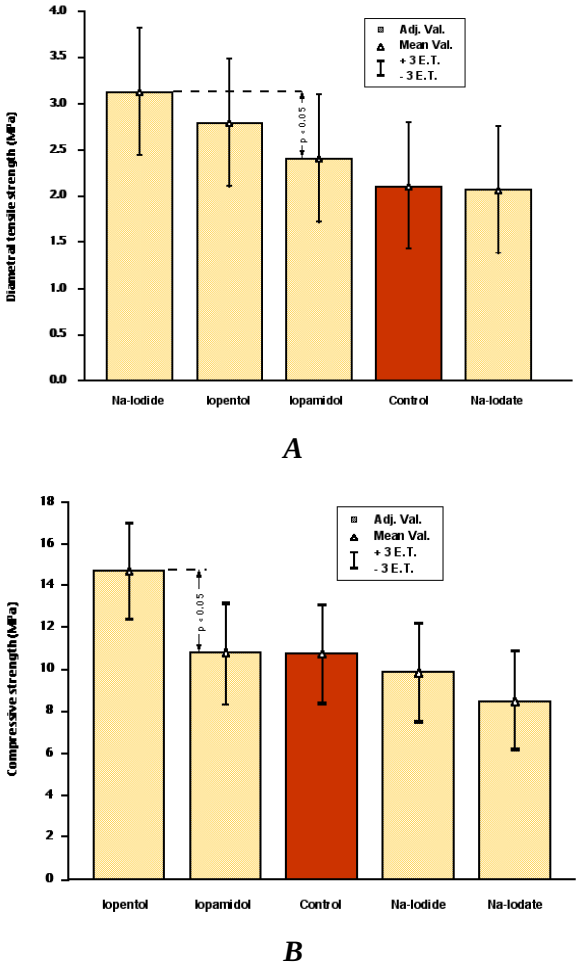

Fig. 1: Mechanical properties of radio-opacified Brushite cements. A) Diametral compressive strength ; B) Uniaxial compressive strength.