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The importance of heat treating nickel based alloys used in fixed prostheses technology

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Introduction

Nickel alloys may be subjected to different types of pre- and post-weld heat treatments, depending on the chemical composition, fabrication requirements and intended use. Ni-Cr alloys used in dental technology belong to the precipitation hardened alloys and their mechanical properties are developed by heat treatment to produce a fine distribution of particles in a nickel rich matrix [1-4].

Objectives

The purpose of the study was to evaluate the effect of heat treatments on microplasma welded Ni-Cr alloys with different composition used in dental technology, by metallographic analyses and microhardness tests.

Material and Methods

The casting alloys used in this study were Ni-Cr alloys: Wirolloy (Ni 63.2, Cr 23.0, Fe 9.0, Mo 3.0, Si 1.8, C < 1.0, Bego, Bremen, Germany), Wirolloy NB (Ni 67.0, Cr 25.0, Si 15.0, Mo 5.0, Mn, Nb, B, C < 1.0, Bego, Bremen, Germany). For the experimental study 16 plates were cast conventionally using an induction melting centrifugal casting machine Orcacast (Π dental, Budapest, Hungary). Half of them were coold slowly at room temperature and half quickly, quenching them in cold water.
After casting, the plates were divested, air abraded with 250µm Al_2O_3 particles, grinded and prepared for welding by polishing and degreasing.
The plates were matched and welded using microplasma Welder (Schütz-Dental, Rosbach, Germany).
Each specimen was bilaterally welded in a butt joint configuration, with a spot overlapping of more than 60%, using 0.5 mm in diameter wolfram electrode for joining and 1 mm diameter for surface fining. The pulse delay was maintained at 30 ms and the argon quantity at 5-6 l/min in all cases. The used power step was 8 for joining and 4 for fining (Fig. 1).
Half of the welded specimens were heat treated using a furnace (Sirio 720S, Sirio Dental, Meldola, Italy), 60 min at 800°C and then cooled uniformly to room temperature. They were analyzed metallographic, and the microhardness was determined in the base metal (BM), weld metal (WM) and heat affected zone (HAZ).

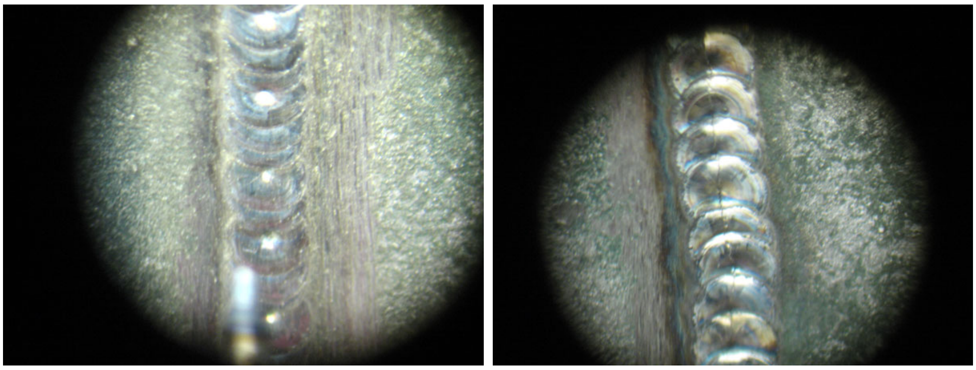

Fig. 1a-b: Microscopically aspect of the welded surface

Results

Cracks appear along the joining line and are propagated along the grain boundaries. The cracks and the modification of the microstructure due to the rapid heating and solidification process can be a real problem and affect the quality of the weld (Fig. 2).

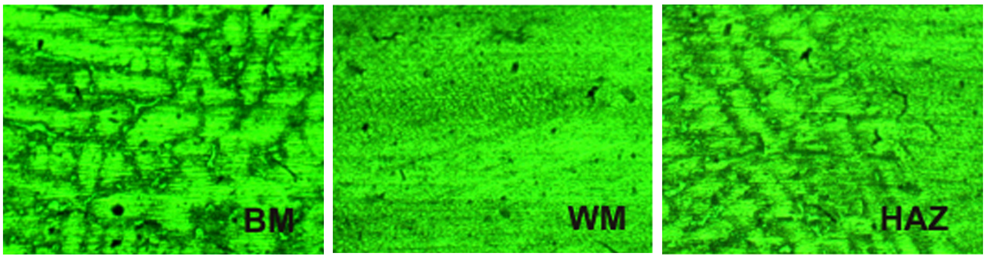

Fig. 2a: Metallographic aspects of the welded samples: Wirolloy

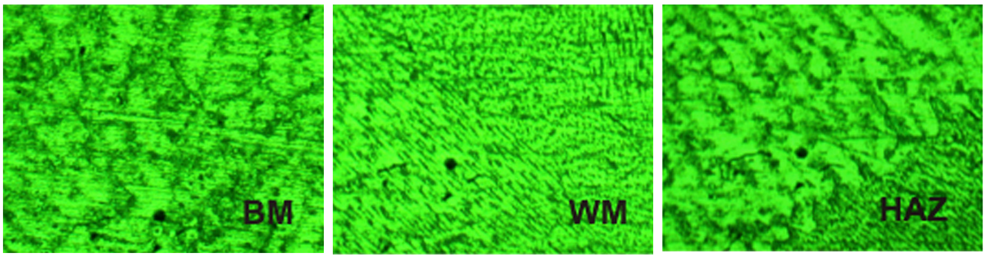

Fig. 2b: Metallographic aspects of the welded samples: Wirolloy with pre-weld heat treatment

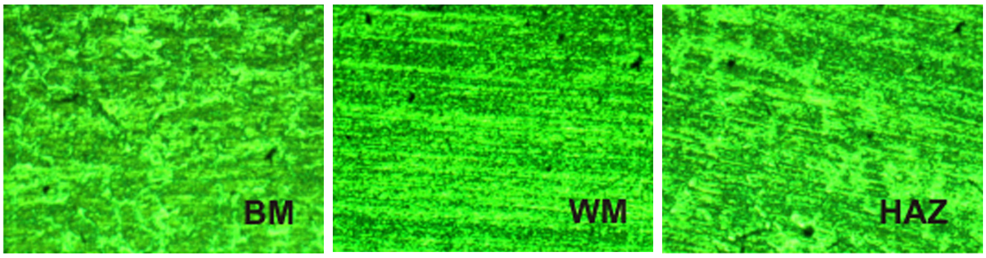

Fig. 2c: Metallographic aspects of the welded samples: Wirolloy NB

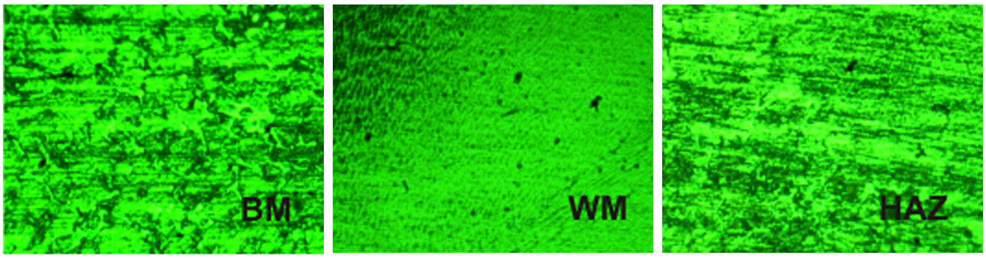

Fig. 2d: Metallographic aspects of the welded samples: Wirolloy NB with pre-weld heat treatment

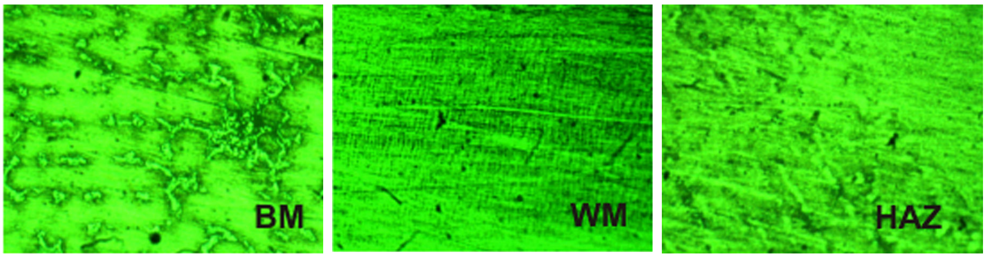

Fig. 2e: Metallographic aspects of the welded samples: Wirolloy with post-weld heat treatment

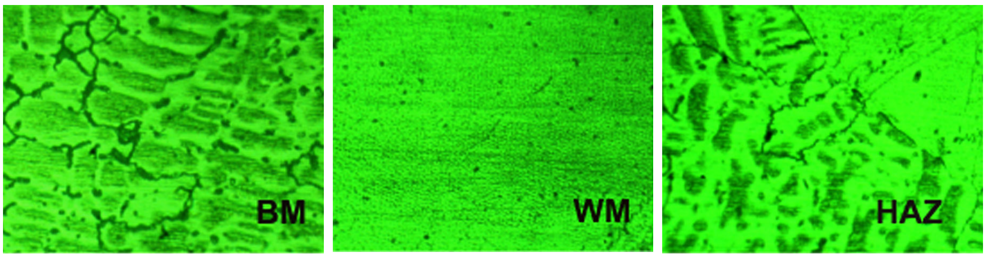

Fig. 2f: Metallographic aspects of the welded samples: Wirolloy with pre-weld and post-weld heat treatment

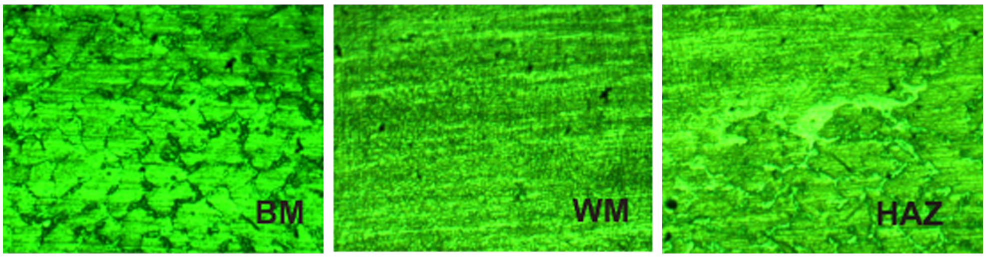

Fig. 2g: Metallographic aspects of the welded samples: Wirolloy NB with post-weld heat treatment

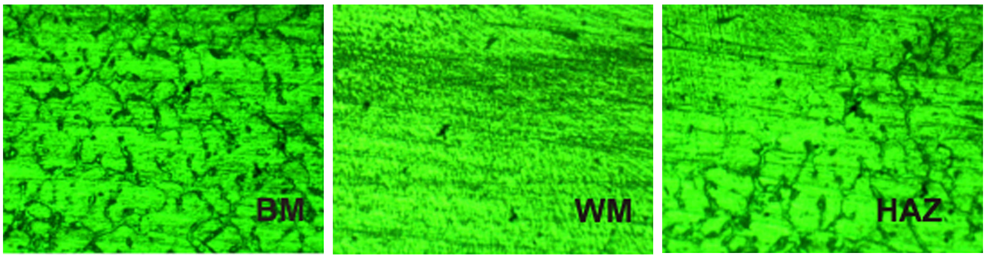

Fig. 2h: Metallographic aspects of the welded samples: Wirolloy NB with pre-weld and post-weld heat treatment

The dendritic microstructure of the BM became finer especially for Wirolloy and the microhardness values decreased after after heat treatments for Wirolloy and increased for Wirolloy NB (Tab. 1).

Sample	Examined area	Microhardness HV1
	BM	224, 229
1	HAZ	257, 251
	WM	229
	BM	239, 214
2	HAZ	263, 269
	WM	251
	BM	251, 245
3	HAZ	269, 290
	WM	290
	BM	234, 214
4	HAZ	276, 251
	WM	269
	BM	159, 201
5	HAZ	197, 219
	WM	193
	BM	201, 197
6	HAZ	201, 245
	WM	189
	BM	305, 389
7	HAZ	348, 321
	WM	290
	BM	313, 239
8	HAZ	321, 276
	WM	358

Tab. 1: Microhardness values for samples 1-8

Conclusions

Even the chemical composition of the alloys was similar; their behavior at heat treatment was different. Therefore it is important that the heat treatments procedures be particularized for each alloy type. The microhardness reduction was obtained only for Wirolloy. Regarding the metallographic structure, the most affected by heat treatment was the same alloy.

Acknowledgements

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Literature

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