NiTi SHAPE MEMORY CLAMPS FOR BONE FRACTURE TREATMENT IN RABBIT: PRELIMINARY REPORT

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Introduction

Most of the fractures of the long bones in rabbits can be repaired using an intramedullary pin and orthopedic wires. However placing the cerclage wire around the fracture site can damage the last vestiges of blood supply from the bone fragments.
As an alternative to that clamps made of the NiTi shape memory wire can be applied. The NiTi alloy is well known from its medical applications [1-3]. It is due to its shape memory effects, high biocompatibility, acceptable resistance to corrosion, especially, when it is applied for a short-term staying in biological environment [4-5].
In presented work, as a support for classical technique for bone fracture fixation, the clamps made of NiTi shape memory were applied.

Materials and Methods

The clamps, with their shape and size, shown in FIG. 1, were prepared from the NiTi wire provided by BHH Mikrohuta (Dąbrowa Górnicza, Poland). The wire was 1.2 mm in diameter.

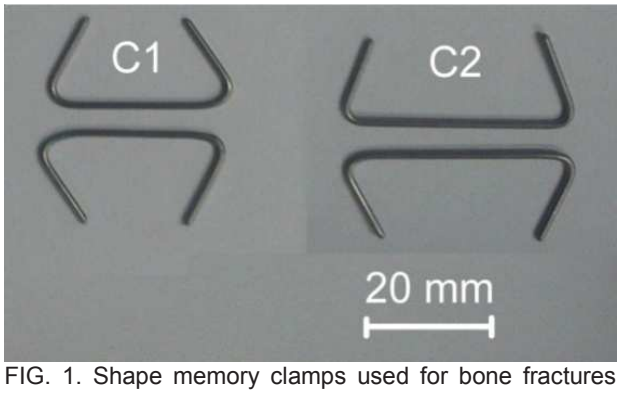

FIG. 1. Shape memory clamps used for bone fractures fixing.

The experiments were carried out on 6-months old rabbit. After the tibial osteotomy, intramedullary fixation was used to stabilize the fracture, the ends of the fracture were secured by one of two kinds of clamps marked as C1 and C2. In order to receive proper stabilization of the bone fragments, they were mounted in different directions. The length, of the working arms of the clamps, was adjusted to a bone diameter.
Thermal range of the reversible martensitic transformation, occurring in NiTi wire, was studies with use of the differential scanning calorymetry (DSC).

Results and Discussion

In order to ensure that clamps are able to reveal shape memory phenomena, the presence and course of the martensitic transformation was studied. Thermograms measured at thermal range between -120°C and 50°C (FIG. 2). It can be found that one maximum and one minimum is present on cooling and heating DSC curve, respectively. Martensitic transformation starts at -35°C (M_s) and finishes at -80°C (M_f), whereas reversible transformation starts at -28°C (A_s) and finishes at -9°C (A_f). The ability to received force from the transformation is determined by enthalpy of transformation. In all clamps its value was about 13 J/g. Obtained parameters of the reversible transformation enabled application of the one-way shape memory effect.

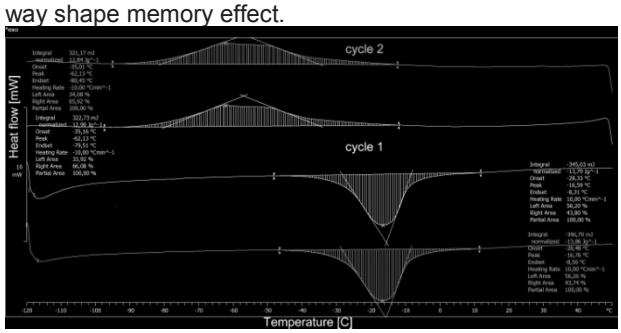

FIG. 2. DSC cooling/heating curves measured for wire used for clamps production.

All these results were used for set up the medical operation. First, clamps were sterilized and cooled down to temperature of liquid nitrogen (below M_s). At that temperature, the arms were bent to 90° position. Then, clamps were fixed in previously drilled holes in both fractures of the broken bone. In result of using heat of the rabbit's body, one-way shape memory effect caused fixation of the bone fragments (FIG. 3).

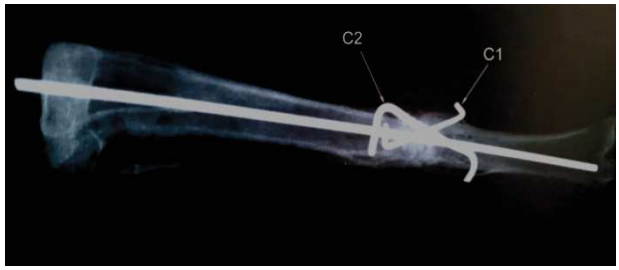

FIG. 3. Radiograph showing fixed bone fracture with use of clamps C1 and C2.

All fractures were radiologically healed at 6 weeks, however clamps were intentionally left for next 6 weeks. After that, the tissue surrounding channel, after clamp removal, was examined. Results proved that no anatomical changes were found.

Conclusions

The NiTi clamps appeared to be alternative supportive way for bone osteosynthesis applied to rabbit. Moreover, bone fractures after 6 weeks were correctly healed.

References

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