A Prototype System for Testing Biomaterials Properties in Controlled Cutting Conditions

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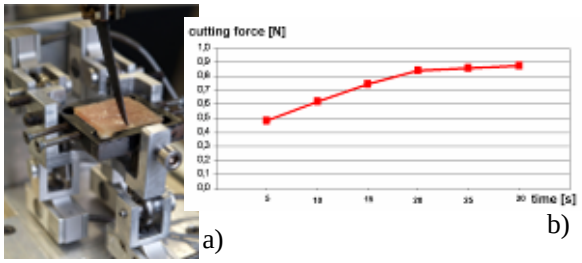
INTRODUCTION: A system for running cutting tests with blades (i.e. surgical scalpels) in controlled conditions has been developed. Cutting motion and forces are computer-controlled, reaction forces and blade-material friction are recorded during the test; moreover, the 3D microtopography of the cut surfaces can be acquired and analyzed. The system can be used to study properties and behaviour of either living tissue or natural or synthetic biomaterials to be subjected to blade cutting, for application in biomedical and surgical fields.

METHODS: The system architecture is composed of two main units: the first (cutting unit) is devoted to the execution of the cutting test in controlled conditions and to the recording of cutting forces and friction; the second (surface analysis unit) is devoted to 3D microtopography analysis of the cut surfaces.
The cutting unit is comprised of: interface for mounting different kinds of blades at various incidence angles; interface for holding specimens; unit for generating the cutting motion with real-time control of speed rates and normal cutting loads; equipment for replicating dry and wet cutting; equipment for measuring forces and friction coefficient during the test; software environment for processing and analysis of measured data, similar work can be found in [1].
The surface analysis unit is comprised of: subsystem for the acquisition of the 3D microtopography of the cut surfaces, equipped with contact sensor (stylus) or optical laser sensor, with submicrometric horizontal and vertical resolutions; software environment for the quantitative analysis of the 3D microtopography reconstructed from measured data [2].

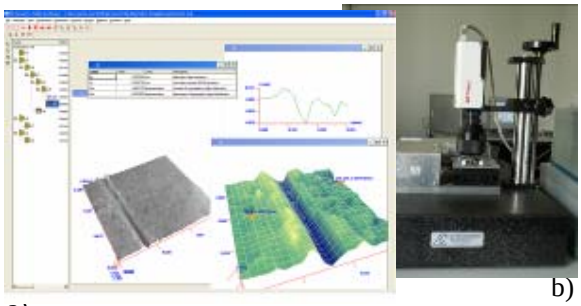
RESULTS: Cutting tests were performed on living tissue (dried pig skin) and polymeric biomaterial (PMMA) with different types of surgical scalpels. Test parameters: cut length 10 mm; cutting speed rate 25 mm/s; constant vertical load 4 N. Tangential and normal forces were recorded and analyzed (Fig.1). The cut surfaces were acquired with the 3D microtopograpy acquisition subsystem equipped with the laser sensor. (Fig. 2.a) and analyzed via software (Fig. 2.b).

DISCUSSION & CONCLUSIONS: The results of the cutting tests performed with the prototype on living tissue and polymeric biomaterial show that the developed system can be successfully used to analyze the properties of different materials as they are subjected to cutting with blades. The system can provide aid to the design and development of innovative biomaterials aimed to exhibit specific behaviour when subjected to blade cutting.



a) b)

Fig. 1: Cutting unit; a) detail of the test in progress (ceramic scalpel cutting dried pig skin); b) cutting normal load as measured by the cutting unit during the test .



a) b)

Fig.2: Surface analysis unit; a) analysis of the 3D microtopography reconstructed from measured data; b) acquisition of 3D microtopography of a PMMA specimen.

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