**Introduction**

Dental implants are widely used clinically and have allowed considerable progresses in oral and maxillofacial surgery. However, implant failures, which may have dramatic consequences, still occur and remain difficult to anticipate. Accurate measurements of implants biomechanical stability are of interest since they could be used to improve the surgical strategy by adapting the choice of the healing period to each patient. Empirical methods based on palpation and patient sensation are still used by dental surgeons to determine when the implant should be loaded because it remains difficult to monitor bone healing *in vivo*.

**Methods**

Firstly, the implant is initially completely inserted in the proximal part of a bovine humeral bone sample in order to investigate the potentiality of quantitative ultrasound to assess the amount of bone in contact with titanium dental implant. The 10 MHz ultrasonic response of the implant is then measured using the set up shown in Fig. 1 and a quantitative indicator is derived based on the rf signal obtained. Then, the implant is unscrewed by $2\pi$ radians and the measurement is realized again. The procedure is repeated several times and the indicator is derived after each rotation of the implant.

Secondly, a 3D finite element model is employed and the geometrical configuration is assumed to be axisymmetric. The sensitivity of the ultrasonic response of the implant to variations of the quantity and quality of bone tissue in contact with the implant is assessed under realistic conditions. Moreover, the effect of the presence of a liquid layer of varying thickness between bone tissue and the implant is assessed and the effect of osseointegration phenomena is estimated.

**Results**

The value of the indicator obtained when the implant was embedded in air is equal to 434.1± 1.7. The value of indicator significantly increases as a function of the number of rotation applied to the implant. Each rotation corresponds to unscrewing by $2\pi$ radians. The average of the standard deviation of the indicator (when the implant is fully inserted in bone tissue) is equal to 1.42. The average of the correlation coefficient corresponding to the linear regression analysis of the variation of the indicator as a function of the number of rotations is equal to 0.91. The average of the slope of the same linear regression is equal to 4.47. The results show that bone quantity in contact with the implant has a significant influence on its ultrasonic response. Analysis of variance ($p<10^{-5}$) tests revealed a significant effect of the amount of bone in contact with the implant on the distribution of the values of the indicator.

The numerical results show that the implant ultrasonic response changes significantly when a liquid layer is located at the implant interface compared to the case of an interface fully bounded with bone tissue. A dedicated model based on experimental measurements was developed in order to account for the evolution of the bone biomechanical properties at the implant interface. Based on the reproducibility of the measurement, the results indicate that the device should be sensitive to the effects of a healing duration of less than one week. In all cases, the amplitude of the implant response is shown to decrease when the dental implant primary and secondary stability increase, which is consistent with the experimental results.

**Conclusions**

This study paves the way for the development of a new ultrasonic tool to be used in implantology for the monitoring of osseointegration.

**References**
