Modelling the effect of bone-implant contact on dental implant pullout and torque removal tests

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Abstract

Osseointegration of dental implants is a key factor for their success. It can be assessed either by destructive (e.g. pullout or torque extraction, histological), or non-destructive methods (e.g. resonant frequency analysis). However, as of today there is a scarcity of models that can relate the outcome of destructive tests to the level of osseointegration.

We studied various percentages of bone to implant bonding (tie) using finite element simulations. While evolutions of the bone mechanical properties are not explicitly taken into account, emphasis is put on the three-dimensional variable extent of the bone-implant bonding, its statistical distribution, and its influence on the measurable extraction and torque loads, seeking to obtain a quantitative relationship.

The following conclusions can be drawn from this study:

- The relative contact area of any implant geometry with the bone components should be determined for better understanding the role of each bone component on the extraction process.
- The trabecular component has a higher contribution to the pullout force and extraction torque due to its high relative contact area.
- Neither pullout test nor torque values can discriminate beyond a relatively low percentage of osseointegration (not exceeding 20%).
- The torque extraction test has a relative advantage over the pullout test in discriminating the percentage of osseointegration.
- Even a limited amount of osseointegration (ca. 20%) appears to be sufficient to confer secondary stability to a dental implant.
- Both contact area percentage and interfacial mechanical characteristics determine the implant stability.