Summary

The primary aim of this thesis was to validate the applicability and accuracy of CBCT for the assessment of the microstructure of trabecular bone. Subsequently, the results of structural analysis of bone were analysed using various scanning protocols, in different regions of the mandible and for different locations of the object in the CBCT field of view (FOV).

The essential role of the trabecular bone microstructure on the success of dental implant treatment is reviewed in Chapter 1. The imaging techniques for the assessment of trabecular microstructures are discussed based on their advantages and drawbacks in oral implant studies. The potential of CBCT in assessing the trabecular structure was visually investigated by comparing images derived from a CBCT system (80μm) with MSCT (650μm) and µCT (35μm). The outcome of this study showed the potential of CBCT in measuring trabecular microstructures in clinical practice.

Chapter 2 describes a study in which 24 human mandibular cadavers were scanned using a CBCT system to simulate the clinical assessment of trabecular bone quality. A µCT system enabling the quantitative analysis of bone volume fraction, trabecular number, separation and thickness of the trabeculae was used as gold standard.

The estimation of bone strength can be enhanced by combining the assessment of bone density and trabecular microstructure. Thus in Chapter 3, a MSCT system was used to assess the accuracy of CBCT in measuring bone density. A novel image processing method was carefully devised to compare the measurements obtained from both systems. The observer reliability and the image analysis method were validated to justify the research findings. The results confirmed the accuracy of CBCT trabecular structural measurements in comparison to µCT measurements. Although a strong correlation between CBCT and MSCT was observed for trabecular bone density, the accuracy of CBCT in comparison to MSCT was unfavorable. The accuracy of the CBCT measurements is discussed extensively in view of the system’s scanning factors in comparison with the µCT (Chapter 2) and MSCT technology (Chapter 3).

Chapter 4 highlights the scanning factors that could influence the CBCT structural measurements. For the purpose of this study, scanning protocols were set through a
combination of five different FOVs, two types of rotation steps (half and full) and scanning resolutions (standard and high). Datasets from the smallest FOV were used as reference model in order to observe the measurement variations that occur in different scanning protocols. The results showed that trabecular bone microstructure parameters are significantly influenced by the FOV regardless of the FOV’s resolution (standard or high) and rotation mode (180° or 360°). In response to these findings the scanning settings that can produce adequate image quality for trabecular structural analysis are presented and the benefits for patient and clinician are discussed.

In addition to the scanning parameters (FOVs, rotation steps and resolution), the reliability of CBCT trabecular measurements at different locations in the x-ray beam are presented in Chapter 5. A block of bone was placed in four locations at the periphery (anterior, posterior, right and left) and in the central region in five different FOVs. The variations were observed by comparing the structural parameters measured at the peripheral regions to that of the central region of each FOV. Although the CBCT trabecular bone microstructural measurements are influenced by the size of FOVs, the variations are also subject to the type of the systems. Therefore, the results are discussed based on the type of the system and the artifacts that are inherent to the CBCT scanning technology.

Chapter 6 evaluates the CBCT structural measurements of trabecular bone at different sites (anterior and posterior) of edentulous human mandibles. Sixteen human mandibular cadavers were scanned using a CBCT system and a µCT system. The result showed that the CBCT structural measurements of different mandibular regions are comparable to those obtained with µCT. Furthermore, the influence of the specimen’s density, the origin and the resolution of the compared systems on the structural analysis are discussed in this chapter.

Finally, the discussion of the study results and recommendations for future research are presented in Chapter 7. The current thesis authenticates the applicability and accuracy of CBCT in assessing trabecular bone microstructures. More studies should be conducted in order to predict the effects of the factors described in this thesis in order to develop a standard clinical protocol for structural bone analysis using various CBCT systems. Eventually, the assessment will be simplified through the advancement in analysis software and computing technology. Then the clinical applications of CBCT will further evolve enabling the
observation of the bone graft integration process, the monitoring of treatment effects and the
diagnosis of systemic and metabolic bone diseases.