上顎中切齒外傷之動態有限元模擬與分析

Dynamic Finite Element Analysis of Dental Trauma in Upper Central Incisor

中文摘要

到目前爲止，有關牙齒受到撞擊力產生挫傷的研究，大多侷限於病理現象、臨床統計與治療技術的探討，而影響牙齒遭受撞擊後反應之力量因素，則尙無完整研究，且有關該力量的作用、傳導以及與臨床現象之關聯性，亦無完整描述。而上顎正中門牙是臨床上最容易發生被撞擊的牙齒，其受撞後可能發生牙冠斷裂、牙根斷裂、牙冠及牙根斷裂、牙齒鬆脫或慢性/急性牙髓喪失活性等現象，但是相關機轉目前仍不明瞭。

本研究是利用動態有限元素分析法，採文獻記載之動態力作爲輸入力量，以及文獻已發表之牙齒楊氏模數、密度與波以松比，同時爲表現出牙齒之黏彈特性，以模態測試法先行量取牙齒整體結構之阻尼比(damping ratio)，再將此特性輸入模型中，以瞭解阻尼特性對牙齒受動態力後應力分佈之影響。此外本研究更進一步探討撞擊力的方向對牙齒斷裂的形成與延伸之機轉。

研究結果發現，牙齒的阻尼比爲 14.6 %，當結構阻尼係數變大時，應力有下降趨勢且其最大值延後產生；就撞擊力的方向而言，垂直向下的力量較垂直向上的力量更容易產生應力集中現象，同時發現水平分量是導致牙冠水平斷裂的原因，而垂直分量則易導致牙根斜向斷裂與唇側齒槽骨斷裂，當角度由垂直向牙根尖方向且與水平齒槽骨夾 77.5 度以及垂直向牙冠方向且與水平齒槽骨夾 70.9 度時，破裂線的延伸是由施力點附近向牙冠切緣處方向進行，而超過此角度時，破裂線是由牙冠切緣處向施力點附近方向延伸；在撞擊角度水平向下 10.1 度或水平向上 13.8 度時，牙齒的斷裂型態則由傾向於唇側牙冠斷裂轉變爲傾向於牙冠水平斷裂。

英文摘要

There are no publications about the directions of impact force as to the structure properties of damping effect in relation to dental trauma. It is still an enigma in propagation of force inside tooth and the pathogenesis of dental trauma. Upper central incisor is considered to be the most frequently involved tooth when an impact occurs. The outcome of such impact could be enamel fracture, crown fracture, root fracture, crown and root fracture, avulsion, luxation and chronic or acute pulp necrosis etc, but the exact mechanism is still unclear.

This study uses the dynamic finite element method to simulate the conditions of tooth under impact force. The input force is drained from an impact record from documents and the damping ratio is from the calculation of an in vivo model testing study. The

young’s modulus, Poisson’s ratios and density of all parts of tooth are from documents. Stress analysis was made by change the directions of impact force and the damping ratios of the model. Our results revealed that the damping ratio of upper central incisor is 14.6 %. When structure damping increased, the maximum equivalent stress decreased and the time is delayed. The directions of impacting forces play an important parameter for assessing the fracture patterns. Intrusive force can cause stress accumulation more easily than extrusive force. Horizontal force is the reason for horizontal crown fracture, while vertical force is liable to oblique root fracture and labial alveolar bone fracture.