利用振動理論分析下顎骨挫傷機轉之研究

Dynamic response analysis of the mechanism of mandible trauma

中文摘要

在顏面骨折中，下顎骨的骨折是很常見的，其發生的位置通常在幾個特定部位，依發生率的先後分別爲髁頭下位置、下顎骨角位置、正中聯合附近、下顎骨體、齒槽位置、上升枝及矢狀突。在挫傷力學的研究學中，由於動態撞擊力量作用的時間，通常只有 1-20 毫秒(ms)，這樣的瞬時動態力量除了會造成撞擊物的整體運動(rigid body motion)，也會使得撞擊物的共振頻率受激發，並同時伴隨著振動發生。由於動態特性分析是分析挫傷機轉的重要依據，因此本研究使用模態測試法搭配有限元素分析，以瞭解下顎骨在受外力撞擊時可能產生的動態響應，藉以瞭解下顎骨的振動與下顎骨骨折之間的關係。實驗方法上，在已乾燥的下顎骨上參考骨折好發的位置規劃 7 個測試點進行體外共振頻率與振動模態的量測，量測得下顎骨的振動頻率平均值爲 578.6±11.67Hz。所建構的三維下顎骨有限元素模型首先進行體外模態測試，計算的頻率爲 567.3Hz，與體外實驗值相比相差 1.9%，利用驗證後之模型模擬正常下顎骨的共振頻率爲 501.4Hz，同時發現當振動發生時，髁突與正中聯合附近將產生較大的振幅與較高的變形，在下顎骨體中點則產生較小的振幅與較低的變形。從此研究結果可以發現，當下顎骨受外力撞擊而產生振動時，其共振頻率與振動模態不會因撞擊位置與撞擊力大小而改變，而因撞擊引發振動所產生的高變形位置，與臨床觀察骨折位置相吻合，此結果表示除了下顎骨本身的形狀，結構，及骨骼的材料性質差異會對下顎骨折造成影響外，受撞擊時下顎骨的振動也扮演了重要的角色。

英文摘要

Mandible fractures are the most common disabling injuries among the facial trauma. Clinical observation found that the usual sites of the mandible fractures are subcondyle region, mandibular angle, parasymphsis, mandibular body, alveolar process, ascending ramus and coronoid process. In traumatic biomechanical analysis, traumatic injuries typically result from an impact force by a hard object. Such impact forces are, in general, of short duration (1-20ms) and most probably give rise to a vibrational response, superimposed on rigid body motion of the impact tissue. Since dynamic response analysis is an important basis for analyzing the mechanism of trauma, to evaluate the possibility for vibrational assessment of mandible, in this study, resonance frequency (RF) are carried out to be a parameter for assessing the relationship between dynamic behavior of mandible and mandible fractures. Ten mandibles positioned on a soft cushion to provide free-free boundary condition were tested by modal testing method. Each mandible was triggered to

vibrate by an impact hammer at 7 points which were designed by the clinical fracture site. Then the RF values and vibration mode were recorded. Our results showed that the RF values fall between 560Hz and 598Hz with a mean of 578.6 ±11.67Hz. Then, RF value of the finite element (FE) modal was calculated as 567.3 Hz which is only 1.9% smaller then the results of in vitro test. That is, the FE modal was validated as a credible modal for dynamic response analysis. The RF value of fresh mandible was then calculated as 501.4 Hz using FE modal. The result was also indicated that the middle area of mandible body is probably a nodal position where bone fracture is less likely to happen. On the contrary, the greatest amplitude was found in the parasymphysis of the mandible and the subcondyle region where bone fracture are prone to occur. These findings corresponded to the probable site of fracture of the mandible usually seen in clinical practice. The results obtained from this study will provide an insight into the basic dynamic properties of human mandible. These experimental results will be an useful reference for future advanced experiments and protective guard design.