牙用複合材及牙本質黏著系統之熱源鍵結解離的有限元素分析

Thermo-debonding mechnism of dental composite and dentin bonding systems

中文摘要

有限元素分析法(finite element analysis;FEA)近年來已廣泛應用於生物力學的領域，以探討生醫材料與組織間以及材料與材料間的界面問題。本實驗即以FEA 來探討牙科常用的複合樹脂其基質與填料間，以及牙本質黏著劑與牙本質間，在給予適當熱源時，材料界面間熱應力的行爲表現。本實驗分兩部分進行。第一部分以填料(矽化及非矽化) 0%, 25%, 50%,75%重量比加入基質後攪拌均勻的模型樹脂，在電子顯微鏡下實測填料與基質距離，據以爲建立電腦模型的參考。第二部分，以三種牙本質黏著劑(Scotchbond MP, Optibond, Tenure,)塗佈牙本質後形成的混雜層(hybrid layer)，亦以電子顯微鏡量測寬度，及對牙本質作用機轉不同，建立不同的模型。另外亦參考先前實驗及相關文獻以求得所需之實驗數據。兩部分的 FEA 均併用 transient 及 steady-state thermal analysis 來求得有時間累積性的熱應力變化。實驗所得結果〔應力線、應力值、能量值〕將與北醫口研所以其他檢測方法所得之數值相互驗證及補足，以期確立材料間微觀的鍵結解離(interfacial debonding)的機制。實驗結果對照本研究室的實驗資料可獲得下述結論：1.以靜態分析及動態分析兩者合併觀察結果，高振幅的訊號來源應是基質與填料界面分解的結果(不論矽化與否及不同填料重量百分比)，而此時材料應從界面破壞。2.應變能與界面的抗剪應力均是衡量材料破壞的指標，而兩者呈現相反關係。3.Scotchbond MP 的高振幅訊號來源爲界面破壞所產生，此與電子顯微鏡觀察結果相同。4. Optibond 的高振幅訊號來源爲基質的破壞，此亦與電子顯微鏡觀察結果相同。5. 5.Tenure 的高振幅訊號分析結果與 Scotchbond MP 相同，但對於塗抹層的作用 6. 兩者不同，此表示有限元素分析的應用不能單獨成立。6.模型轉換的模擬中，7. 顯示了〝elastic cavity wall concept〞在臨床上的重要性。

英文摘要

Finite element analysis(FEM) has been widely used in biomechanics, for evaluatingthe interfacial relationship in interior of biomaterials or between natural tissues. Using FEM, the study evaluated the thermal stress behavior, under the application of laser power, of interfacial relationship between filler and matrix of dental composite. First, according to former experiment, SEM, and referred papers, we created the FEM model, including different filler weight volume(0%,25%,50%,and 75%). The decision of properties (elastic

modulus & thermal expansion coefficient) of silane coupling agent is assumed to the best conductivity of thermal stress, otherwise, we proposed a third material which blocks the thermal stress between filler and matrix as unsilanated model. Commercial computer program(ANSYS 5.3)is used in the study. The thermal load solution is based on transient couple-field analysis, and the model was constrained in Y-direction on X-axis and X-direction on Y-axis for 1/4 model symmetry. The results showed that 1. the stress distribution patterns of 0% and 25% model composites are similar that possible destruction in the outer field of heated area. 2. 75% model composite is possible destroyed in the inner and outer field of heated area. 3. the strain energy of silanated group is higher than that of unsilanted group, indicating more destruction-resistance. The result is comparable to that of LAETT , designed in our laboratory room, and show that FEM is a available method in studying the thermal-debonding mechanics of interior of materials.