様式３

論　文　内　容　の　要　旨

氏　　名　（　　近藤　聡太　　）	
論文題名	Development of treatment and diagnostic techniques for dental caries using light based on minimal intervention （ミニマルインターベンションに基づく光を用いたう蝕の治療、診断技術の開発）

論文内容の要旨

Caries is a disease caused by decalcification due to organic acids such as lactic acid produced by metabolism and degradation of sugar in a dental plaque on a tooth surface. Especially, root caries is a dental disease that affects more than one in three persons in the geriatric population. In recent years, a minimally invasive dental treatment for teeth corresponding to a concept of minimal intervention was strongly desired. As a minimally invasive treatment, a caries selective removal had not been achieved with the conventional microsecond-pulsed Er:YAG laser due to the thermal effect. In this study, the possibility of the caries selective removal with nanosecond-pulsed *Q*-switched Er:YAG laser satisfying the thermal confinement condition was suggested. However, the caries selective removal could be possible with the dentin hardness as a caries status, and the methods to measure dentin hardness have not existed for clinical use or been still qualitative. Therefore, this study developed a dentin hardness measurement method to objectively and quantitatively evaluate the activity and progress of root caries in a clinical setting. This technique was called “HAMILTOM.” With the demonstration of HAMILTOM using bovine dentins with different demineralization times, the correlation between the dentin hardness measured by HAMILTOM and measured by the Vickers hardness tester was evaluated. Moreover, the mechanism of dentin hardness measurements and the invasiveness to dentin were evaluated in this study in order to interpret the dentin hardness measured by HAMILTOM physically.

Chapter 1 provided the background of caries and root caries. The trend of minimal intervention for caries treatment was provided. To realize the philosophy of minimal intervention, the significance of a treatment of selective removal for caries and a method to objectively and quantitatively measure the dentin hardness to prevent unnecessary treatment were presented.

Chapter 2 provided the possibility of selective removal for caries with nanosecond-pulsed *Q*-switched Er:YAG laser at the wavelength of 2.94 μm to develop a less-invasive laser caries treatment using the laser. The characteristics of laser ablation to dentin slices were examined and compared between the *Q*-switched Er:YAG laser with a pulse duration of 80–130 ns and the free-running Er:YAG laser with a pulse duration of 200–300 μs without water spray. The results confirmed that the ablation selectivity of the caries model was observed at a low peak power density and the suppression of dental pulp necrosis due to the temperature increase by the laser irradiation could be possible. However, in the clinical situation, the condition and the degree or progression of caries are various, which suggested that the optimal condition of laser irradiation for each caries could be unclear. The caries selective removal could be difficult to achieve in the clinical situation without the information of dentin hardness.

Chapter 3 provided the proof of principle of the optical dentin hardness measuring device using bovine dentin. In order to evaluate the activity and progress of caries in a clinical setting, an objective and quantitative method to evaluate dentin hardness which can be used easily in the clinical setting had to be established. In this study, the new device was proposed to easily measure the hardness of *in vivo* teeth using a light-emitting diode. HAMILTOM quantified the hardness of dentin from the contact projection area (dark area) between the indenter and dentin when the indenter was pressed into the dentin. The results of the demonstration of HAMILTOM confirmed that the correlation between the dark area and the Vickers hardness.

Chapter 4 discussed the mechanism of dentin hardness measurements and the invasiveness to dentin by HAMILTOM because the measurement mechanism for quantitative dentin hardness evaluation had remained unclear. The mechanism was discussed by the result of the difference between dark areas and indentation areas, and the invasives to dentin was discussed by comparing the invasiveness to dentin with the conventional dental probe. The results suggested that the dentin hardness (dark area) measured by HAMILTOM included not only the deformation of dentin but also the exuded water from dentin. The comparison of the indentation depths suggested that palpation by a dental probe caused the larger indentation depth than HAMILTOM.

Chapter 5 provides the overall conclusion. HAMILTOM has the potential of a new diagnostic device for caries and a strong support for the realization of selective removal for caries to measure the dentin hardness in a clinical setting.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

近藤聡太氏の博士論文 Development of treatment and diagnostic techniques for dental caries using light based on minimal intervention(ミニマルインターベンションに基づく光を用いたう蝕の治療、診断技術の開発)は、Chapter1: Introduction、Chapter2: *In vitro* study on nanosecond-pulsed Q-switched Er:YAG laser-induced selective removal for caries dentin、Chapter3: Demonstration of an optical dentin hardness measuring device using bovine dentin with different demineralization times、Chapter4: Mechanism of dentin hardness measurements using an optical dentin hardness measuring device、および Chapter5: Conclusion で構成され、ミニマルインターベンションに基づいて、レーザーを用いたう蝕選択的治療技術、LED を用いたう蝕診断技術に関する研究結果が示されている。Chapter1 では、ミニマルインターベンションという、う蝕治療に関する基本理念実現に基づき、う蝕選択的治療、さらに低侵襲な治療実現に向けた歯の硬さ定量評価技術の必要性、博士研究の目的に関して論じている。Chapter2 では、熱閉じ込め条件を満たすナノ秒パルスの *Q* スイッチ Er:YAG レーザーを用いたう蝕選択的治療技術に関する研究結果を示しており、有効性および安全性に関して、う蝕選択的治療実現の可能性を示している。また、歯の硬さを定量する意義に関して論じている。Chapter3 では、う蝕診断技術として、LED を用いた光学式歯質硬さ測定技術の原理実証を行っており、従来の硬さ指標であるビッカース硬さとの相関性を確認している。Chapter4 では、光学式歯質硬さ測定装置による測定された硬さ指標(減光面積)の物理的解釈を行っており、メカニズムに関して追究している。光学式歯質硬さ測定装置によって測定された減光面積と象牙質に形成された圧痕の比較より、減光面積は象牙質の変形だけでなく、圧子の押し込みにより染み出す水分の影響が含まれていることを示している。また、臨床応用していく上での安全性に関しても評価しており、従来の触診で用いられる歯科用プローブとの侵襲性比較評価より、光学式歯質硬さ測定装置の侵襲性の低さを示している。最後に、Chapter5 にて、博士研究目的に対する研究結果に関して論じている。以上のように、本論文は、ミニマルインターベンションに基づくレーザーを用いたう蝕選択的治療技術、および LED を用いたう蝕診断技術研究を行い、う蝕選択的治療の実現可能性、LED を用いた光学式歯質硬さ測定技術の原理実証およびその測定メカニズム解明に関する成果を示すことができている。よって本論文は博士論文として価値あるものと認める。