〔ORIGINAL〕

# Histologic investigation of tissue surrounding bone in a HA-coated implant supported super structure with and without stress-absorbing elements

Yasuhiro IKEDA, Toshihiro HIRAI, Toshihiko YAJIMA*, Tsutomu ISHIJIMA, Hisashi KOSHINO, Yoji KONISHI, Hiroshi KANEKO, Takanori OHGITANI, Kazuyuki OOMORI** and Makoto ARISUE**

Department of Removable Prosthodontics and Department of Oral Anatomy*, Department of Oral Surgery**
Health Sciences University of Hokkaido School of Dentistry,
Hokkaido, Japan

(Chief : Professor Toshihiro HIRAI)
*(Chief : Professor Toshihiko YAJIMA)
**(Chief : Professor Makoto ARISUE)

## Abstract

The effectiveness of the implant-supported overdentures has been attracted attention for edentulous patients, and a number of studies have been reported. Implant-supported overdentures refer to implant-retained tissue-borne overdentures and it is different from the implant-supported fixed partial dentures recommended by Brånemark. In implant-supported overdentures, the functional load may concentrate on implant where there is rigid connection. Loaded implants may cause a resorption of surrounding bone, leading to malfunction, loosing, and the ultimate failure of the implant.

The present study reports a stress-absorbing element using a resilient compound designed as the super structure of a two-piece titanium core with hydroxyapatite coated cylinder implants, to avoid stress concentrations, and a histological comparison of the surrounding bone tissue with rigid elements.

No notable histological differences were observed in the trabecular patterns by contact microradiography and light microscopy.

**Key words :** Implant-supported overdenture, Hydroxyapatite-coated implant, Stress absorbing element, Implant/bone interface

Accepted : October 13, 1997

## Introduction

There is a high rate of edentulism among the elderly in industrialized countrise[1,2]. With edentulous patients, the effectiveness of implant-supported overdentures has attracted attention and a number of studies have been reported[3-5]. However, there are still many problems such as the connection between denture and implants acting as abutments.

Ichikawa et al[6] indicated that an stress-absorbing elements would be necessary for implant-supported overdentures to compensate for subsidence of denture base due to the stress concentrated on the implant as abutments in rigid connections. Loaded implants may cause resorption of surrounding bone, which leads to malfunction, loosing, and ultimate failure of the implant. It is suggested that high stress may lead to resorption of bone, and it appears possible to avoid high stress concentrations by changing the mechanical and physical properties of the super structure.

In the study, the influence of implant-supported superstructures with and without the stress-absorbing elements on the surrounding bone tissue was investigated histologically.

## Materials and methods

A mixed breed dog (body weight 20Kg) was used in the study. The first and second mandibular premolar teeth were extracted bilaterally under general anesthesia. After 4 months, implant sites were prepared using high-torque, low-speed, twist and spade internal irrigated drill at approximately 500 rpm. Four 8mm-long two-piece titanium core, cylindrical implants with hydroxyapatite (HA) (Integral, Calcitek Inc.) were placed at the crest level. Implants were seated with finger pressure and tapped lightly with a mallet. Complete gingival closure was achieved with the subgingival implants and flap approximation to the pregingival series. Implants remained buried for 3 months.

The implants were exposed three months after the insertion and two types of prosthetic heads were placed as super structure, cementing and stress-absorbing types. The cementing type of prosthetic head was fabricated by conventional casting using 12% gold-silver-palladium alloy and cemented on the implants. The absorbing type of prosthetic head was fabricated by conventional casting with the same alloy and a 0.5mm space between inside of the prosthetic heads and the abutment for insertion of regular type Molteno (Molten Medical Co., Japan) as a stress absorber. A 1.0mm diameter. retention hall was prepared at the central portion of the buccal and lingual surface of the absorbing type prosthetic heads and abutments for the fixation of the prosthetic heads on the abutment by 0.25mm diameter orthodontic wire. The opposing upper molar teeth were restored by full coverage metal crowns to regulate the occlusal cuntact.

Until sacrifice, the animal was given a solid diet during 4 month experimental period. The prosthetic heads were brushed and cleansed weekly. The mandibular containing the implants was fixed in 10% buffer enutral formalin and subsequently dehydrated in graded ethanol, and

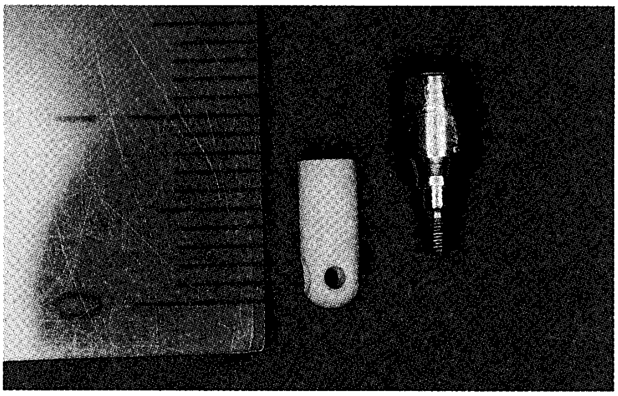


Fig. 1 Two-piece titanium core with hydroxyapatite coated cylinder implant (Integral, Calcitek Inc.)

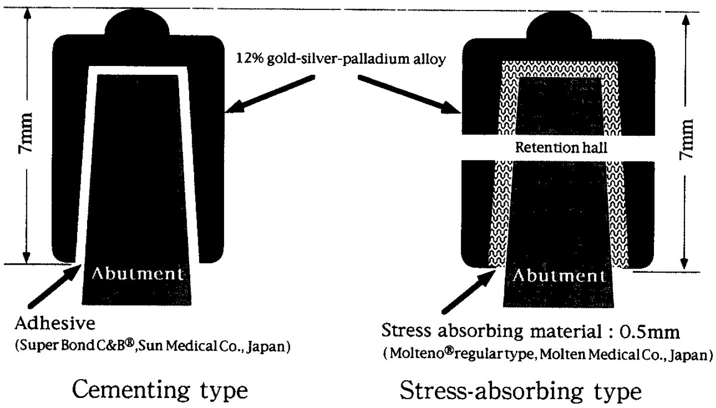



Fig. 2 Schematic drawing of the 2 types of super structure

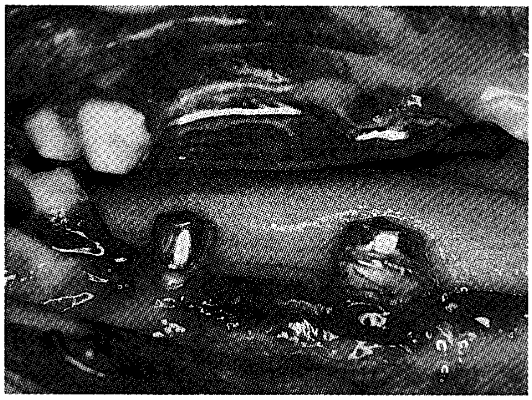


Fig. 3 Opposing upper molar teeth restored by fullcoverage metal crowns

embedded in Rigolac. The ground sections, including the 70$\mu$m thick HA-coated implants were made by a diamond cutter in the sagittal section and contact microradiographs (CMR) were taken. Toluisin blue staining of the specimens was mede after nondecalcified ground sagittal sectioning. The bone and implant junction was subjected to light microscopic examinations.

## Results

### 1. Clinical observation

No clinical mobility of implants and no signs of tissue inflammation around the gingival area, except for the mesial side of the stress-absorbing type, were observed until the time of retrieval. There was a pocket (3-5mm depth) at the mesial side of the gingiva in stress-absorbing type implant. The remaining marginal gingiva showed a similar appearance to the neighboring natural teeth.

**2. Histologic observation**

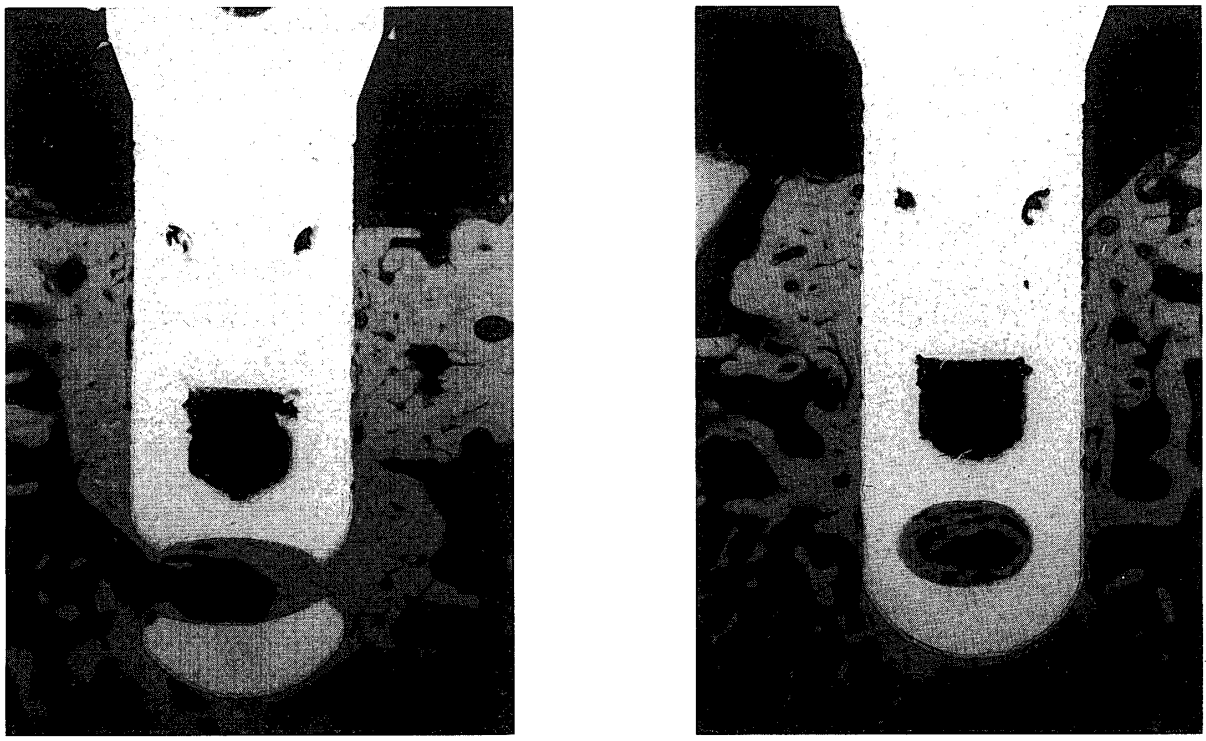
Except for the mesial side cervix of stress-absorbing type implant there were no notable histological differences between the cementing and the stress-absorbing types by the contact microradiographic and light microscopic observations.

1) Cementing type

Epitherial cells showing downwards growth around the implant was limited to half the gingival thickness. The marginal gingiva had scattered inflammatory cells. Epithelium and connective tissue (lamina propria) adapted well to the HA-coated surfaces of the implants. The implants were surrounded by bone and the contours of the crestal bone was smooth. Bone was directly attached to the HA-coating without any soft tissue layer and continuos with surrounding trabecular bone. No connective tissue layer could be observed between the HA-coating and the bone. Bone grew into the hole of the implant.

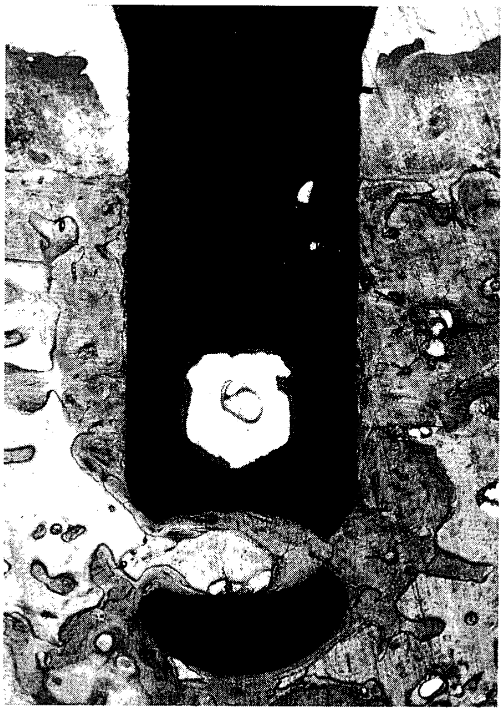
2) Stress-absorbing type

There were no distinguishing differences between the stress-absorbing and cementing types, except at the mesial side of the implant. In this region, epithelial cells grew downward to the crestal bone. There was inlfammation characterized by deep pocket formation. Further, there was inflammation and numerous chronic imflammatory cells in the epithelium and connective tissue. There were osteoclasts on the crestal bone surface, and crestal bone resorption was observed. Therefore, the contours of the mesial crestal bone was irregular. The HA-coating

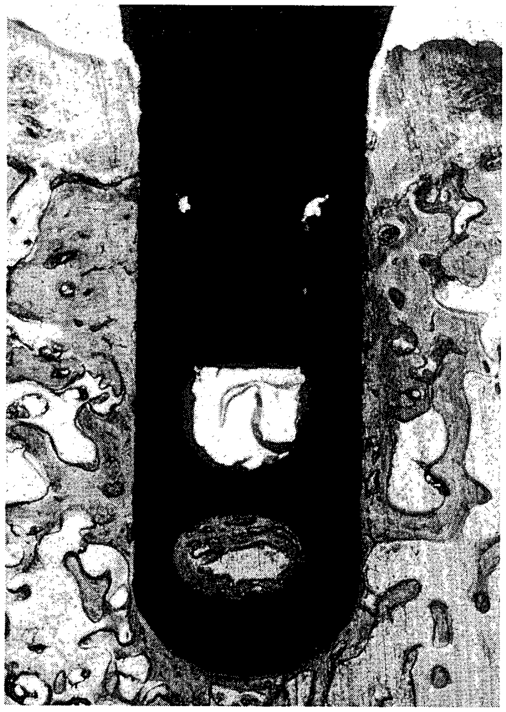


Cementing type Stress-absorbing type

**Fig. 4** Softex type contact microradiographic findings



Cementing type



Stress-absorbing type

Fig. 5 Light microscopic findings

had disappeared at the bone-resorption area, however, the bone bonded directly to the HA-coating in the other areas in the same manner as with the cementing type.

## Discussion

Free standing implants started in 1978 with the aluminum oxide implant, and other metallic, carbon, and ceramic implants have been tested[7-9]. Recently there has been high success rates with HA coated implants[10-12]. Spectrophotometric studies[13] have demonstrated a chemical bond at the interface between bone and implant in HA coated implants, showing the close relationship between bone and hydroxyapatite, better than the direct connection between bone and implant in Brånemerk osseointegrated implants[14].

An overdenture is defined as a removable partial or complete denture that covers and rests on one or more of the remaining natural teeth, roots, and/or dental implants[15] where the functional load is transmitted to the teeth or the implant and the residual ridge. The implant -supported fixed partial denture is a "jaw bone-anchored bridge" pioneered by the research of Brånemark et al. Where the load is directly transmitted to the implant fixture by abutment cylinders[15]. The implant-retained tissue-borne overdenture is dependent on soft tissue support from the residual ridge nexted to the implant. In this case the implants and connecting structure, usually a bar, are responsible for retaining the super structure absorbing the occlusal load[16].

Rigid support of removable partial dentures is a common concept in prosthodontics. In general, the displacement range of a natural tooth is 100～150$\mu$m and 500$\mu$m for the mucous membrane of the residual ridge. These tissue formations have a viscouselastic body and the rigid support is achieved by designing a denture base which is as large as possible. The displacement range of endosseous implants is 20～30$\mu$m and the curve of displacement of endosseous dental implants assumes an elastic deformation pattern[17]. Considering this, it seems undesirable to apply the usual design of overdentures to an implant-supported overdenture. In this study, the effect of stress absorbing elements on the surrounding bone tissue in implant-supported super structures was investigated histologically.

About stress transfer characterisitics of implants with a rigid or resilient internal element, McGlumphy et al[18]. reported that the static load conditions of the study model demonstrated no statistical difference between the stress patterns generated in a bone simulant by an IMZ (Interpore International) implant with figid or resilient internal elements interposed. French[19] compared the distribution of peri-implant stress transmitted by some implant designs by photoelastic analysis and reported that the IMZ and Integral designs were more effective in reducing stress concentrations along the implant/bone interface than the Core-Vent (Core-Vent Corp.) and Screw-Vent (Core-Vent Corp.) designs. Takeshita et al[20]. also reported no histologic differences except in the cervix between IMZ implants with a rigid and resilient internal elements. The study did not find no differences in the trabecular patterns of cementing and stress-absorbing types. The HA-coated implants formed a good bond with the gingiva epithelium, connective tissue, and alveolar bone. Gingiva epithelium and connective tissue play a very important role in protection against bacterial invasions. There are two possibilities for the cause of the mesial, crestal bone resorption in the stress-absorbing type. One is related to bacterial invasion due to plaque accumulation in the developing pocket. The other involves a separation of the HA-coating during the insertion of the implant.

The findings of our study suggest that mechanical stress such as occlusal and/or masticatory pressure is not blocked by the stress absorbing element. Previous studies indicated that the maintenance of occlusal and/or masticatory pressure was important to maintain bone mineral density at the attachment of masseter muscle to mandible and condyle in old rats[21,22]. This indicates that the prosthetic treatment for edentulous patients using implant-supported overdentures (the implant-retained tissue-borne overdenture) would to be effective to control disuse atrophy of alveolar bone as well as recovering masticatory functioning because of the load pressure on both implants and residual ridge.

## References

1. Phipps, K.R., Reifel, N. and Bothwelle, E.: The oral health status, treatment needs, and dental utilization patterns of native American elders. J. Public. Health Dent., 5 : 228-233, 1991.

2. Medical Affairs Bureau Ministry of Health and Welfare Japan: Reports on the survey of dental disease. Edited by Division of Dental Health Medical Affairs Bureau Ministry of Health and Welfare, 112-113, Japan, 1987.

3. Debore, J.: Edentulous implants : Overdenture

versus fixed. J. Prosthet. Dent., 69 : 386-390, 1993.

4. Parel, S.M.: Implants and overdenture hte osseointegrated approach with conventional and compromised applications. Int. J. Oral Maxillofac. Implants, 1 : 93-99, 1986.

5. Golec,T.S.: Three year clinical review of HA coated titanium cylinder implants, JOI, 14 : 437-454, 1988.

6. Ichikawa, T., Wigianto, R., Amitani, H., Horiuchi, M., and Matsumoto, N.: Basic studies on implant-supported tissue-bone overdenture, J. Jpn. Prosthodont. Soc. 40 : 136-142, 1995.

7. Driskell, T.D. and Heller, A.L.: Clinical use of aluminum oxide endosseous implants, Oral Implantology, 7 : 53, 1977.

8. Meffert, R.M.: Vitreous carbon root-replacement system, Final report, Implantology, 11 : 268, 1983.

9. Kawahara, M., Yamagami, A and Hirabayashi, M.: Bioceram-A new type of ceramic implant. The First Proceedings of The Japan Society of Implant Dentistry 187, 1975.

10. Yucan, R.A.: Results with 322 Integral (HA-coated) dental implants over 3-5 years, J. Dent. Res., 71 : 256, Abstract 1204, 1993.

11. Stultz, E.R., Loofland, R. and Sendax IV : A multicenter 5-year retrospective survival analysis of 6200 Integral implants, Compend. Contin. Educ. Dent., 14 : 478-486, 1993.

12. Block, M.S., Gardiner, D., and Kent, J. N.: Hydroxyapatite-coated cylindrical implants in the posterior mandible. Int. J. Oral Maxillofac. Implants, 11 : 36-45, 1996.

13. Denissen, H.W., Veldhuis, A.H. and van den Hooff, A.: Hydroxyapatite-titanium implants. Proceedings of international Congress on Tissue Integration in Oral and Maxillofacial Reconstruction, Current Practice Series, 29 : 389-394, Excerpta Medica, Brussel, 1985.

14. Brånemark, P. I., Zarb, G. A. and Albrektsson, T: Tissue-Integrated Prostheses ; 11-76, Quintessence, Chicago, 1987.

15. The Academy of Prosthodontics: Grossary of Prosthodontic Terms, Six edition, J. Prosthet. Dent., 71 : 41-116, 1994.

16. Adrian, E.D., Krantz, W.A. and Ivanhoe, J.R.: The use of processed silicon to retain the implant-supported tissue-borne overdenture, J. Prosthet. Dent., 67 : 219-222, 1992.

17. Sekine, H., Kishi, M., Komiyama, Y., Hotta, H., Yoshida, K., Takamatsu, Y. and Kono, T.: A consideration on load supporting mechanism of the osseointegrated implant. Advanced Prosthodontic Worldwide, Hiroshima, 198-199, 1991.

18. McGlumphy, E.A., Campagni, W.V. and Peterson, L.J.: A comparison of the stress transfer characteristics of a dental implant with a rigid or a resilient internal element, J. Prosthet. Dent., 62 : 586-593, 1989.

19. French, A. A., Bowles, C. Q., Parham, P.L., Eick, J. D., Killoy, W.J. and Cobb, W.J.: Comparison of peri-implant stress transmitted by four commercially available osseointegrated implants, The International Journal of Periodontics & Restorative Dentistry, 9 : 221-229, 1989.

20. Takeshita, F., Takata, H., Murai, K., Yamasaki, A., Morimoto, K. and Suetsugu, T.: Histologic observation of IMZ implants in dog. A pilot study using POM-IME and Ti-IME, J. J. Oral Implant, 7 : 39-43, 1994.

21. Hashikawa, Y.: Histomorphometric Study on age-, diet- and teeth loss-related changes in rat condyle. J. Stomatol. Soc. Jap., 60 : 440-468, 1993. (in Japanese, English abstract)

22. Ikeda, Y., Hirai, T. and Yajima, T.: Histomorphometric study on occlusal support loss-, dietary alteration-, and age-related changes in the attachment of masseter muscle to mandible in old rat, Dentistry in Japan, 33 : 63-66, 1997.