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Processing design using mechanoluminescence on epiphysis plates

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Abstract

Mechanical properties of processing design on surgical epiphysis plates were investigated using a mechanoluminescent (ML) sensor. Some size of small dots, 1 and 2 mm of diameter, were processed on the epiphysis plates from the viewpoint of operability using forceps. Through conventional mechanical tests using strain gages, the strain of the processed epiphysis plates was still remaining within 110 % of original plate. On the other hand, through mechanoluminescent evaluation, it was clarified that strain was concentrated even around the processed small dots, however the value was much less than the one at around tapped holes which was processed originally on the epiphysis plates. Thus, the processing of the small dot doesn't make a serious mechanical effect such as stiffness reduction and smaller dots is more appropriate in the purpose. From the results, we successfully demonstrated Mechanoluminesence has highly potential for Processing design on medical and surgical equipment.

1. Introduction

Mechanoluminescent (ML) material is a novel functional ceramic powder and it can emit intensive light repeatedly accompanied by mechanical stress such as deformation, friction, impact, even in elastic deformation region [1–3]. When dispersedly coated onto a structure, each particle acts as a sensitive mechanical sensor, while the two-dimensional (2D) emission pattern of the whole assembly reflects the dynamical strain/stress distribution [1–11], as shown in Fig. 1.

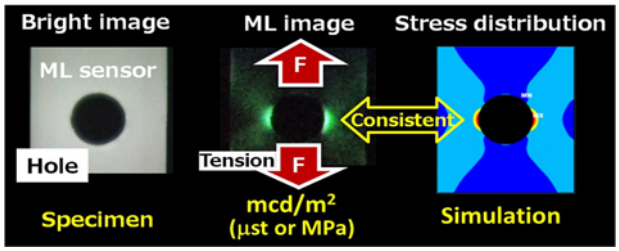

Fig. 1 Mechanoluminescent (ML) sensing, reflecting dynamic strain distribution.

The ML sensor has been applied to real social infrastructure such as bridge [3-8], building [3, 9], welding point of pipeline [3] hydrogen high pressure vessel [10] and CFRP and adhesion [11], and it successfully demonstrated the ability to detect active crack, real crack propagation and mechanically weak points etc. as a portent of destruction.

Meanwhile, not only the social structures and industrial parts but also bio-body is always under influence of various mechanical load, and the bio-tissues, artificial surgical implants and nursing care equipment should be also taken care from the mechanical aspect. In addition, the equipment sometime remains difficulty in the aspect of operability. Concretely, Fig. 2(a) is schematic illustration of surgical operation of broken bone using an epiphysis plate and screws for fixing. At the moment of screwing, the bone and the epiphysis plate should be tightly holding using forceps to maintain right position. However, point of forceps easily slip on the titanium epiphysis plates and this make the operability difficult.

Here, some size, 1 and 2 mm of diameter, of small dots were processed on the epiphysis plates from the viewpoint of operability using the forceps. Strain distribution and strength reduction were evaluate using 2 methods: (1) strain gage method as conventional way and (2) Mechanoluminescent sensing method. As the results, it was clarified that the processing of the small dot doesn't make a serious mechanical effect such as strength reduction, and we successfully demonstrated Mechanoluminesence has highly potential for processing design on medical and surgical equipment.

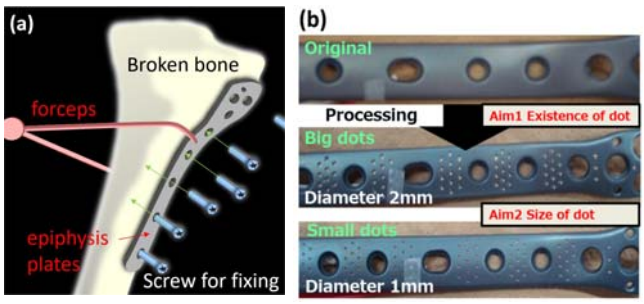

Fig. 2 (a) schematic illustration of surgical operation of broken bone using an epiphysis plate and screws for fixing, (b) photograph of original and processed epiphysis plates.

2. Experimental

The epiphysis plate was commercial one, made by titanium (MIZUHO Co.,Ltd). The processing of the small dots with the size of 1 and 2 mm were carried out by processing and machining company (Shotoku Zerotec co.,ltd).

After the processing, a ML paint [3, 5, 7-11], consisting of $SrAl_2O_4:Eu^{2+}$ ML ceramic powder (denoted as SAOE, λ_{em}=520 nm) and epoxy resin, was coated on the surface of the original and processed epiphysis plates using an air splay

(Fig. 2). In addition, 3-axial strain gage was put at the backside of the plate. Load was applied using a weight of 80 N in the mode of tension and Three-point bending test. A CCD and commercial video camera was used to record the dynamic ML emission pattern related to the stress distribution in real-time [2, 3, 10, 11]. All ML measurements were carried out under dark condition.

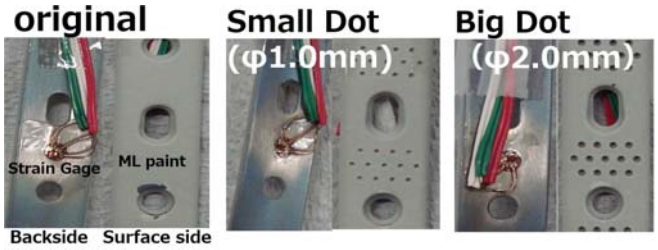

Fig. 3 Photograph of original and processed surgical epiphysis plates, coated with ML paint.

3. Result and Discussion

From all test pieces, similar ML pattern was observed at around originally processed screw hole. On the other hand, stress concentration was also observed at round the newly processed small dot. From the ML luminance, the value of strain was calculated and it was found that the strain value in big dot was larger than the one in small dot. This shows that small dot is appropriated for compatibility of operability and mechanical strength. Furthermore, the strain value at around big dots was much smaller than the one at around tapped holes which was processed originally on the epiphysis plates. This clearly shows that the processing of the small dot doesn't make a serious mechanical effect such as stiffness reduction.

4. Conclusion

Mechanical properties of processing design on epiphysis plates were investigated using a mechanoluminescent (ML) sensor. Some size, 1 and 2 mm of diameter, of small dots were processed on the epiphysis plates from the viewpoint of operability using forceps. Through mechanoluminescent evaluation, it was clarified that strain was concentrated even around the processed dots, however the value was not serious. From the results, we successfully demonstrated mechanoluminesence has highly potential for Processing design on medical and surgical equipment.

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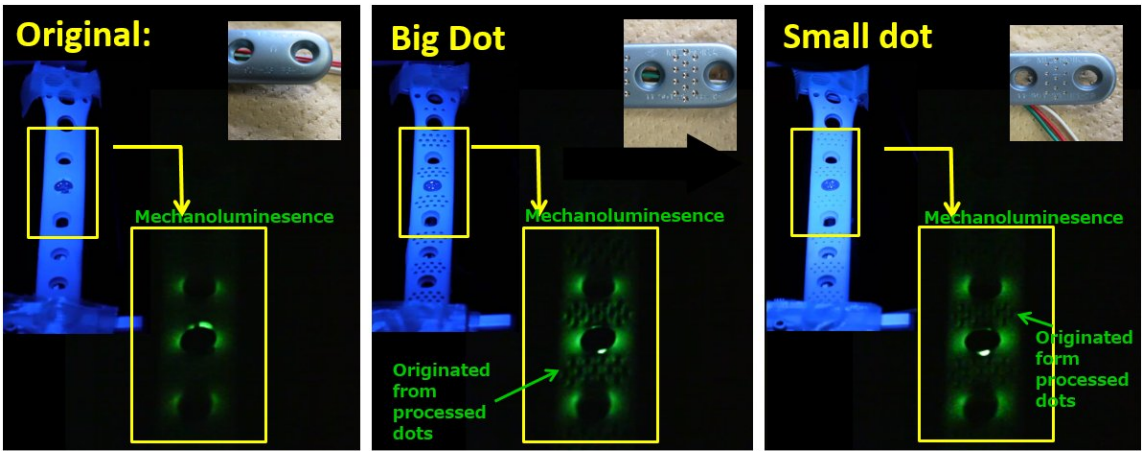

Fig. 4 ML results from original and processed surgical epiphysis plates at the moment of bending load application