MECHANICAL EVALUATION OF THERAPEUTIC EFFECT FOR OSTEOPOROSIS VERTEBRA BY USING PATIENT-SPECIFIC FINITE ELEMENT ANALYSIS

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INTRODUCTION

To evaluate risk of compression fracture of osteoporosis vertebrae, current diagnosis methods such as measurements of bone mineral density by DXA are not sufficient, because mechanical strength is not evaluated directly. Mechanical strength of vertebra depends on patient-specific factors, which are shape, cortical thickness, density distribution of cancellous, material properties of bone tissue, and so on. So that patient-specific mechanical analysis is required. In previous study, finite-element (FE) analyses based on CT images of osteoporosis patient's vertebrae were carried out and its availability was confirmed. In this study, FE analyses of osteoporosis vertebrae undergoing drug treatment were also performed over time. Effect of drug therapy to mechanical strength recovery of vertebrae was discussed.

METHODS

Analysis target was L1 vertebra because it was located near the inflection point of spine and favorite site of osteoporosis fracture. X ray CT images were taken at 1mm intervals from 4 osteoporosis patients. All of them were Japanese female whose age was 60, 53, 71 and 72 years old respectively. Patient-specific FE models of L1 based on CT images were obtained by using "Mechanical Finder (RCCM Co.)" as shown in figure 1. This is computer software for bone strength analysis considering individual bone shape, cortical thickness and bone density distribution. Shell elements were used for cortical bone. Young's modulus of each element was given one by one calculating from bone density and CT value. Relationship between the mechanical properties and bone density proposed by Keyak [1] was used. Simple compressive loading was considered, that is, bottom surface was fixed and uniform pressure was applied to upper surface of vertebra [2].

RESULTS AND DISCUSSION

Figure 2 shows density and compressive principal strain distribution of model A at the central section before and after therapy. Drug effect in the model A was most significant. High-density area increased after therapy initiation at cortical bone and whole cancellous bone. After a year, local high strain region before therapy was almost disappeared and cancellous bone strain were totally reduced. It would be effective to prevent compression fracture of vertebra. Figure 3 shows average density and compressive principal strain of the 4 models. Drug therapy seemed to work for reinforcing strength of vertebrae in case A and B. Drug effect was also observed in case D, even though average density was not changed. Bone trabecular structure seems to be changed reducing average strain in this case.

CONCLUSIONS

Strength recovery of osteoporosis vertebra due to drug therapy was analyzed quantitatively by patient-specific FE analysis.

REFERENCES

1. Keyak JH, et al., *J Biomech* **31**, 125-133, 1998.
2. Nachemson A, et al., *Spine* **6**, 93-97, 1981.

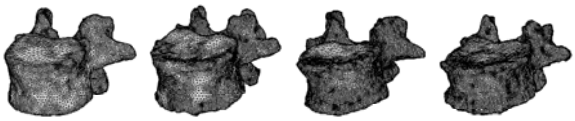

Figure 1: Patient-specific FE models of L1 before therapy

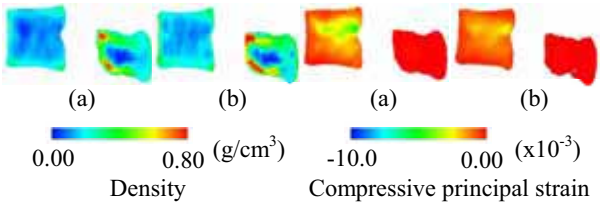

Figure 2: Density and compressive principal strain distribution of model A at central section (a: before therapy, b: after a year)

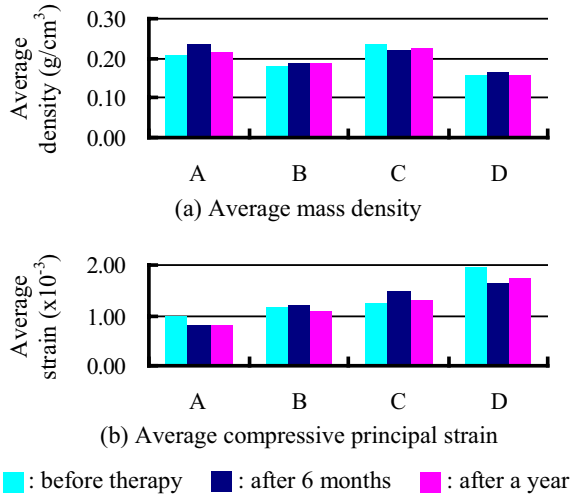

Figure 3: Average density and compressive principal strain of L1 for the patient-specific models