ISSN 1340-8763

The Japan Society of Mechanical Engineers Vol.13, No.1 May,2002

Jsme News

URL http://www.jsme.or.jp/English

From recent inaugural address

The JSME for the Year 2002 and Beyond

Yoshimi ITO,

President for 2002
Dr.-Eng. F JSME, C Eng F IEE (UK)
Professor Emeritus of Tokyo Institute of Technology
Zentrum für kooperative und interdisziplinäre Innovationsforschung e.V.

The JSME is a self-governing body with a long history as a learned society in publicising valuable engineering publications, in disseminating engineering knowledge, in promoting the qualification of engineers and in assisting the personal development of engineers with the aim of sustaining their professional skills.
The JSME has however expanded its activities in the professional sphere to a large extent. With dramatic and unpredictable advances and changes in the technological, economic and social environments, the JSME has also had to look to its own development while anticipating actively and passively the social pressures for change.

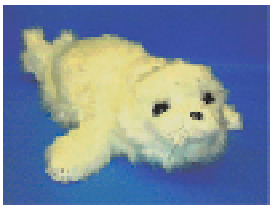
Continued on page 2

Entertainment Robotics

Takanori Shibata

Intelligent Systems Institute
National Institute of Advanced Industrial Science and Technology

The field of robotics has been expanding well beyond its initial concentration on industrial robotics. Entertainment robots represent such interesting expansion. They have another long history as "Machine made to make the person enjoy and relax." There was "automata" in Europe in the Middle ages and was "mechanism doll" in Japan of the Edo age. They were luxurious goods and their technology was the highest at the age. New technological innovation was caused because of the development of automata and mechanical doll.



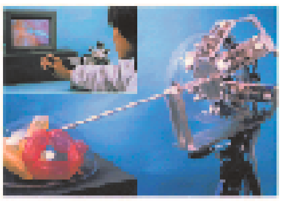
Continued on page 3

Recent Progress of Medical Robotics in Japan

Koji Ikuta Professor

Department of Micro System Engineering
Graduate School of Engineering
Nagoya University

One of the most exciting areas in advanced robotics in Japan is medicine. Various kinds of robotic tools for minimally invasive surgery and non-invasive examinations have been developed over the last five years. Unlike in the United States and Europe, the main thrust of research in Japan has been greatly supported by university researchers, because, most Japanese medical companies are extremely conservative in developing active tools for use in patients compared with passive tools



Continued on page 5

Biodegradable Porous Scaffolds for Tissue Engineering

Tetsuya Tateishi

Professor
Biomedical Engineering Laboratory,
Graduate School of Engineering,
The University of Tokyo

Development of Tissue Engineering
1. Biomaterials and Tissue Engineering
The therapies of damaged or lost tissues include tissue transplantation, surgical reconstruction, drug therapy, synthetic prostheses, and medical devices. Tissue or organ transplantation is restricted by an insufficient number of donors. Although the other therapies are not limited by supply, they also have problems.

Continued on page 6

From recent inaugural address

The JSME for the Year 2002 and Beyond

Yoshimi ITO, President for 2002 Dr.-Eng. F JSME, C Eng F IEE (UK)

Professor Emeritus of Tokyo Institute of Technology

Zentrum für kooperative und interdisziplinäre Innovationsforschung e.V.

Continued from page 1 From 1997 (75th Term) the JSME has been at the forefront in establishing new organisational structures, creating real and virtual information networks for the interchange of knowledge about engineering and, in part, researching culture and mindset issues, understanding of which will be imperative for the profession's position within society in the very near future. For example, even production engineers must have an understanding of social-, cultural- and mindset-related facets in the era of multiple-nationality harmonised manufacturing. In short, the JSME must respond to the "Highly Information-Reliant and Aged Globalised Society" and be attractive not only to members but also to all engineers within mechanical engineering-related spheres. This means the JSME must promote the qualification of all mechanical engineers through life-long, problem solving-based and distant learning, must be especially responsive to the increasing number of engineers who, through internationalisation, are self-employed and who need a qualification certificate which is valid across the whole world, and must contribute to the needs of society for the realisation of a comfortable life style.

The three primary roles of the JSME for the time being have already been stated by the immediate past President Mr. Toshio Kobayashi, Dr.-Eng., Professor of the University of Tokyo [1] and are reproduced as follows.

(1) To provide members with valuable engineering information of higher quality.
(2) Both to sustain professional competence and to maintain a high standard of professional conduct among members.
(3) As a leading professional society, to collaborate with other academic organisations to coordinate, for instance, their roles in governmental policy for future engineering development.

In close relation to these primary roles, various activities have been carried out under the control of the immediate past President Mr. Toshio Kobayashi and with immeasurable voluntary contribution from the past Executive Board of Directors, Chairs of Divisions and Branches and members concerned.

Bearing in mind these roles and considering both the importance of the continuity of activities and the challenging attitude of society, the determinants of the 80th term (2002) should be the establishment of the JSME as a leading network hub providing technological information of the highest quality as well as fostering engineers who have a higher potential for both leading research and development and conducting the daily work of an engineer across the whole world. In this context, all stored publications should at least be re-evaluated from both the point of view of quality and circulation taking into account the potential benefits of electronic publication.

More specifically, the targets for the year 2002 are fourfold and fall within the ambit of the key strategy formulation.

"Constellation of Outcomes Produced from the Innovative Plans of the JSME for the 2nd Generation"

(1) As an extension of the activities so far conducted, centres both for Promotion of Research and Development and for Engineering Education must be established. It is expected that these will contribute to the cultivation of human resources and also the enhancement of technological co-operation with industry. In special respect to world-wide recognition of qualifications of mechanical engineers, the JSME has been very keen to co-operate with the JABEE (Japan Accreditation Board for Engineering Education) through the accreditation of university educational programmes and also to support CPD (Continuing Professional Development) for engineers.
(2) Reinforcement of internationalisation. The JSME has been endeavouring continuously to reinforce international co-operation. However, internationalisation continues to grow in importance. A forum of Asian Societies for Mechanical Engineers has already been launched, on the occasion of the Autumn Annual Meeting in 2001 and a "Virtual Overseas Branch" is being planned. However, the ultimate aim of the JSME must be the establishment of a successful multiple-nationality representative body.
(3) Considerable academic and engineering knowledge so far accumulated within the JSME should be publicised in the form of, for example, engineering guide books and design data. In this context, at burning issue is a plan for the publication of books written in English based on the complete works of leading engineers within our country. Importantly, each book

should obviously be worth publishing from both the academic and engineering viewpoints and should furthermore provide us with noteworthy evidence and knowledge from the science and engineering history point of view. In addition, we can expect to contribute to other professional bodies and individuals by providing information of higher quality, as yet unpublished in English but only reported in Japanese.

(4) The establishment of "Virtual and Real Intuitive DOJYO (Japanese Physical and Mental Discipline Hall)" to foster young high-calibre engineers. At the moment, a DOJYO is about to be launched by Dr. Kiuchi, Emeritus Professor of the University of Tokyo, who has gathered a team of collaborators across the whole Asian region. The DOJYO is being financially supported by Mori Seiki, a leading machine tool manufacturer. The principle concerns of the DOJYO are to provide the young engineers with opportunities to cultivate the self-innovation ability and create the people-to-people network worldwide together with getting used to several foreign languages by themselves. It can, in short, be expected to foster young engineers, who will have a higher potential to contribute vigorously both to international co-operative work and to internationally competitive work with self-sustainable attitude.

In due course, the JSME aims to establish stable financial budgets at the same time enhancing and reinforcing its valuable services to members.

To this end, it is again emphasised that the JSME should always consider how to be compatible with a society that is both older and makes greater use of information technology.

[1] Kobayashi T. "New Challenges for the JSME", JSME News, June 2001: 12-1; 1-2.

Entertainment Robotics

Takanori Shibata, Intelligent Systems Institute
National Institute of Advanced Industrial Science and Technology
& PRESTO, JST

Continued from page 1 In addition, the derivation goods were invented, and a lot of derivation technologies had been applied to other fields. This paper introduces recent research and development of entertainment robots not only at amusement parks, museums, and exhibition, but also at home, school, hospital and so on. Entertainment robots do not provide us physical labor, but give us mental effects and motivate us.

There are four categories of entertainment robots in terms of interaction with humans as follows:

(1) Performance Robot
(2) Tele-operated Performance Robot
(3) Operation Robot
(4) Interactive Robot with human

First, performance robots include robots at exhibitions and amusement parks such as Disney Land and Universal Studio. King Kong figure and robotic dinosaurs of Jurassic Park the Ride at Universal Studio are famous examples. Spring show of Bellagio Hotel in Las Vegas is another interesting example of performance robot. In Japan, a robot fish swims in an aquarium (Fig. 1). Recent humanoid robots such as Honda's ASIMO and Sony's SDR can be included in this category. A performance robot amuses many audiences at a time. However, its movements are preprogrammed and repetitive, and so they are not interactive with humans. Complexity of performance of robots is important to keep amusing humans.

Fig. 1 Coelacanth Robot (Mitsubishi Heavy Industry)

Second, tele-operated performance robot is controlled by a hidden operator remotely. Its movements are reactive to its audiences because the operator senses action of audiences and sends commands to the robot. At exhibitions or amusement parks, human-type robots are used. Ford used a humanoid robot developed by SARCOS at various expositions. An operator wearing a sensor suit controlled the robot.

Third, operation robot gives fun to a human by its operation or programming. The human watches performance of the robot by his operation. A simple example is "UFO catcher" at amusement centers. In addition, building and programming a robot is included in this category. Contests of robots such as micro-mouse and RoboCup, are popular examples. LEGO Mindstorms is another example of entertainment robot. As building and programming a robot stimulate children's creativity, this is combined entertainment with education, and is referred to as "edutainment."

Fourth, interactive robots have various kinds of sensors and react to stimulation by their environments with some intelligence. Interaction with such robot gives a human fun. Autonomy and intelligence are key technolo-

Fig. 2 AIBO (SONY: ERS-210 model)

Fig. 3 Necoro (OMRON)

Fig. 4 PaPeRo (NEC)

Fig. 5 Wonder (Matsushita Electric Industrial Co.)

Fig.6 SealRobot: Paro (Shibata, AIST)

(a) at Play Room

(b) at Ward

Fig 7 Robot-Assisted Therapy at Hospital

Fig. 8 Robot-Assisted Activity at Elderly Institution

gies in this category. Contrary to robots in other categories, interactive robots are mostly personal use. Interactive robots include AIBO (Fig. 2), Necoro (Fig. 3), PaPeRo (Fig. 4), Kuma (Fig. 5), Seal (Fig. 6), and so on. Recent research shows other roles of interactiverobot than entertainment. Interactive robot heals human's mind. Robot-assisted therapy at a hospital and robot-assisted activity at an elderly institution are good examples (Figs. 7 and 8). In the robot-assisted therapy, moods of children were improved by interaction with the robot. Moreover, the robot encouraged children to communicate with each other and caregivers. In one striking instance, a young autistic patient recovered his appetite and his speech abilities during the weeks when the robot was at the hospital.

Entertainment robots are becoming a new industry out of electronic dogs and cats, and toys that can serve both as a technology playground and, potentially, as a platform for consumer electronics. Entertainment robots offer a proving ground where diverse electrical, mechanical and computer engineers can test, develop and apply their latest technology. Leading technology are emerging here that will later transfer to other application areas.

References

[1] T. Shibata, et al., Emotional Robot for Intelligent System - Artificial Emotional Creature Project, Proc. of 5th IEEE Int'l Workshop on ROMAN, pp. 466-471 (1996)

[2] T. Shibata and K. Tanie, Emergence of Affective Behaviors through Physical Interaction between Human and Mental Commit Robot, Journal of Robotics and Mechatronics, Vol. 13 No. 5, pp. 505-516, 2001

[3] T. Shibata, et al., Mental Commit Robot and its Application to Therapy of Children, Proc. of the IEEE/ASME Int'l Conf. on AIM'01 (July. 2001) paper number 182 and 6 pages in CD-ROM Proc.

[4] T. Shibata, et al., Robot Assisted Activity for Senior People at Day Service Center, Proc. of Int'l Conf. on Information Technology in Mechatronics, pp. 71-76, 2001

Recent Progress of Medical Robotics in Japan

Koji Ikuta Professor

Department of Micro System Engineering

Graduate School of Engineering

Continued from page 1 An important issue of modern medicine is how to achieve non-invasiveness, the elimination of pain and physical damage to a patient, and minimal invasiveness, the minimization of such pain and damage. There has been increasing expectations in recent years for the use of robots and micromachines in non-invasive examinations and minimally invasive surgery.

Laparoscopic surgery is an typical example of minimally invasive therapy that is widespread use. In this surgery, an endoscope and multiple forceps are inserted through small incisions approximately 10 mm in diameters formed in the peritoneum in order to remove gall bladders without open surgery. Endoscope guiding robots assisting in this operation have been commercialized in a U.S. venture. In Japan several prototypes of laparoscopic manipulators with more sophisticated functions are being developed and tested on animals. In Professor Dohi's Lab. at the University of Tokyo, a small robot manipulator with parallel link has been developed for gripping the endoscope. The design of the manipulator is noted for its safety and ease of sterilization.

A manipulator for aiding in brain surgery was developed to help surgeons navigate to three-dimensional positions in a patient's brain while the patient is exposed to the strong magnetic field of an MRI scanner. The manipulator is composed entirely of nonmagnetic materials so as not to disrupt the magnetic field. A longer manipulator for conducting brain surgery within an open MRI is being jointly developed by Dr.Chinzei's Surgical Assist Technology Group at National Institute of Advanced Industrial Science and Technology (AIST) and the Harvard Medical School.

Special robots are being developed for the field of telemedicine, which has been limited in remote diagnosis by conventional image transmission. In an angiorrhaphy microsurgery experiment, images and manipulator operations were transmitted over the high speed Internet between professor Mitsuishi's lab. at the Univ. of Tokyo and medical school of Okayama University. Experimental master-slave manipulater were produced to perform remote micro surgery in open surgery manner.

One of promising research targets of "non-invasive" inspection are active endoscopes such as an active gastroscope to check intestinal cancer. After professor Ikuta, et al., developed the world's first active endoscope driven by shape memory alloy servo actuators, there have been several studies based on similar ideas. Recently, a miniature version of this device so called "safe active catheter" without any electric current inside of the blood vessel was developed in Professor Ikuta's lab. at Nagoya University.

Virtual reality approach in medicine, which are closely related to medical robots, are also becoming popular. These applications can be divided roughly into preoperative simulations and training for inexperienced doctors. A training system wherein trainees open up virtual bodies and remove organs, and a surgery simulation system with force sensation have been developed in the Professor Suzuki's lab. at Juntendo Medical University. At Professor Toriwaki's lab of Nagoya University, a lot of experiments have also been conducted on real-time simulations that accurately reconstruct image data from

Fig. 1 Laparo-Navigator: Laparoscope controlling robot. This manipulator achieved an intrinsic safety and possibility of sterilization by a five-bar linkage mechanism and an optical zooming. (Professor Dohi's lab. at University of Tokyo)

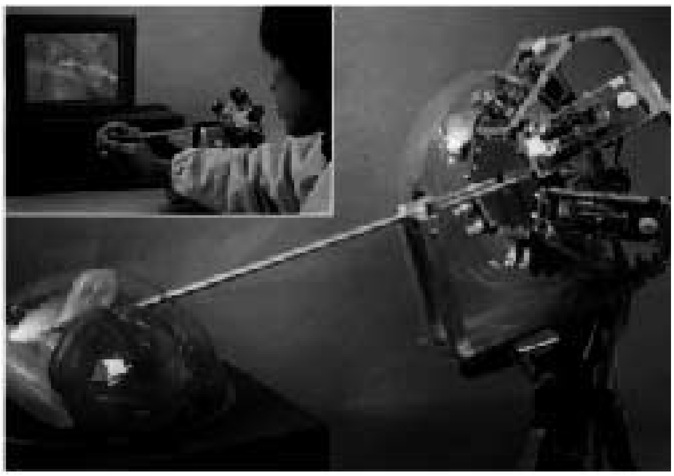


Fig.2 Hyper Finger with hyper redundant degrees of freedom for remote laparoscopic surgery in deep site. Doctor can handle organ by using master-slave hyper fingers whose diameter is 10 mm.

MRI and the like in a computer. These experiments enable operators to conduct diagnoses on simulated body data and insert endoscopes for examinations. The U.S. is promoting a virtual human project conducted jointly by multiple universities and research institutes, while Japan has developed a virtual endoscope that enables the operator to navigate freely into a virtual intestine reconstructed from CT data to detect cancer in the intestinal wall.

Recently, another type of virtual endoscope system with force sensation has been developed in Professor Ikuta's lab. at Nagoya University for recreating a reaction force from the intestine to the surgeons' hand that is indispensable for training doctors in endoscopic insertion. By inserting an actual endoscope into this device, the interactive force between a virtual colon and a virtual endoscope is calculated in real-time, and a special endoscope guiding controller allows the operator to experience a reaction force in the axial direction of the endoscope and a reaction torque. In the field of medical virtual reality, we are seeing a trend of more sophisticated requests from image data to the aforementioned dynamics data.

The research described above is on par with the highest level in the world. By making use of high-level technologies developed by Japanese firms in mechatronics and robotics to achieve practical uses, we anticipate an economic effect that will spawn a new market structure.

References

(1) Etsuko Kobayashi, Ken Masamune, Ichiro Sakuma, Takeyoshi Dohi, Daijo Hashimoto A New Safe Laparoscopic Manipulator System with a Five-Bar Linkage Mechanism and an Optical Zoom Journal of Computer Aided Surgery, pp.182-192, 4(4), 1999

(2) Koji Ikuta, Koji Iritani, Junya Fukuyama, Mobile Virtual Endoscope System with Haptic and Visual Information for Non-invasive Inspection Training, Proc. of the 2001 IEEE Robotics and Automation Conference ,pp.2037-2045(ICRA'01), (2001).

Biodegradable Porous Scaffolds for Tissue Engineering

Tetsuya Tateishi

Biomedical Engineering Laboratory, Graduate School of Engineering,

The University of Tokyo

Continued from page 1 For example, synthetic prostheses and medical devices are not able to replace all the functions of a damaged or lost organ or tissue. The efforts to address these problems and their limitations have elicited the development of new biomaterials and alternative therapies. Tissue engineering has emerged as one such promising alternative approach in treating patients suffering from these problems.[1),2)] Tissue engineering involves the expansion of cells from a small biopsy, followed by the culturing of the cells in temporary three-dimensional scaffolds to form the new organ or tissue. By using the patient's own cells, this approach has the advantages of autografts, but without the problems associated with adequate supply.

With the approach of tissue engineering, porous three-dimensional temporary scaffolds play an important role in manipulating cell functions. Isolated and expanded cells adhere to the temporary scaffold in all three dimensions, proliferate, and secrete their own extracellular matrices (ECM), replacing the biodegrading scaffold. Therefore, in addition to permitting cell adhesion, promoting cell growth, and allowing retention of differentiated cell functions, the scaffold should be biocompatible, biodegradable, highly porous with a large surface to volume ratio, mechanically strong, and capable of being formed into desired shapes. A number of three-dimensional porous scaffolds fabricated from various kinds of biodegradable materials have been developed and used for tissue engineering of liver, bladder, nerve, skin, bone, cartilage, ligament, and etc..

2. Hybrid Scaffold of synthetic Biodegradable polymers and Collagen [3)-6)]

Porous three-dimensional scaffolds fabricated from synthetic biodegradable polymers such as PGA, PLA, and PLGA have been widely used in the tissue engineering of cartilage, bone, skin, ligament, etc.

A new method has been reported to prepare porous scaffolds of synthetic biodegradable polymers by combining porogen leaching and freeze-drying techniques using preprepared ice particulates as the porogen material3) Ice particulates were formed by injecting cold deionized water into liquid nitrogen through a capillary. The formed ice particulates were almost spherical. Their diameters could be controlled by the spraying speed and travel distance. Polymer solutions in chloroform were precooled to -20℃, then mixed with the ice particulates. The dispersion was then vortexed and poured into an aluminum mold. This process was conducted in a cool room (4℃). The dispersion was frozen by placing the mold in

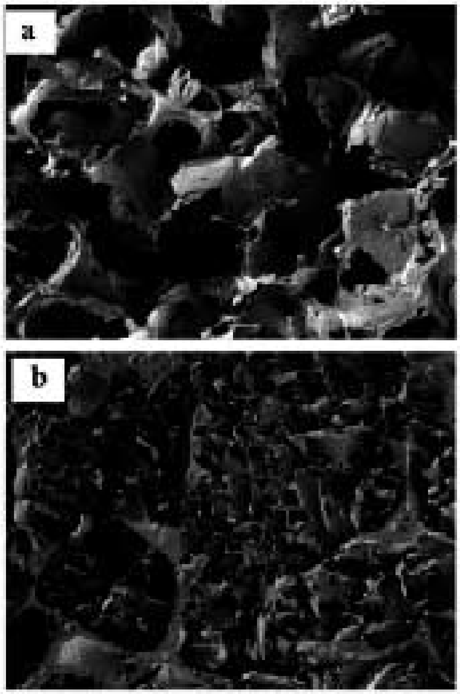


Figure 1. SEM photomicrographs of cross sections of (a) PLGA sponge fabricated by particulate-leaching method and (b) PLGA-collagen hybrid sponge.

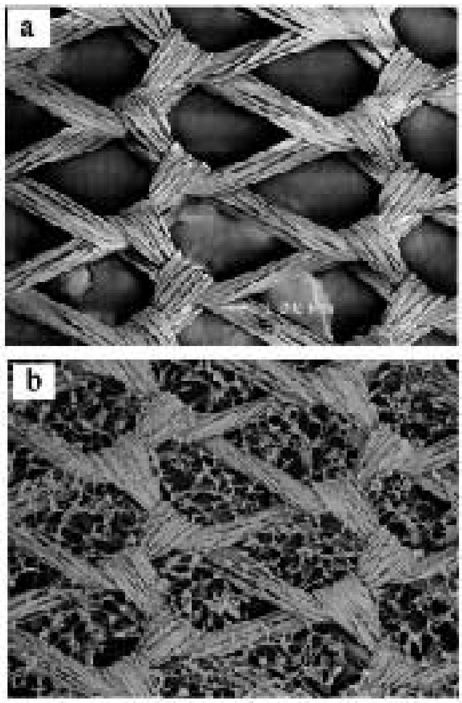


Figure 2. SEM photomicrographs of (a) PLGA knitted mesh and (b) PLGA-collagen hybrid mesh.

liquid nitrogen, freeze-dried for 48 h under liquid nitrogen freezing and for another 48 h at room temperature to completely remove the solvent to form the synthetic polymer sponges.

The synthetic biodegradable polymers used for tissue engineering are easily formed into desired shapes with good mechanical strength. Their periods of degradation can also be manipulated by controlling the crystallinity, molecular weight, and copolymer ratio of lactic acid to glycolic acid. Despite these advantages, the scaffolds derived from synthetic polymers lack cell-recognition signals, and their hydrophobic property hinders smooth cell seeding. In contrast, naturally derived collagen has the potential advantages of specific cell interactions and hydrophilicity, but scaffolds constructed entirely of collagen have poor mechanical strength. Therefore, these two kinds of biodegradable polymers have been hybridized to combine the advantageous properties of both constitutes.

To prepare the hybrid sponges of synthetic polymers and collagen, the sponges of synthetic polymers were immersed in a collagen solution under a vacuum so that the sponge pores filled with collagen solution. The synthetic polymer sponges containing the collagen solution were then frozen and freeze-dried to allow the formation of collagen microsponges in the sponge pores.

The hybrid structure of the PLGA-collagen hybrid sponge is shown in Figure 1. Collagen microsponges with interconnected pore structures were formed in the pores of the PLGA sponge. SEM-electron probe microanalysis of elemental nitrogen indicates that microsponges of collagen were formed in the pores of the PLGA sponge and that the pore surfaces were coated with collagen.

By the similar method, the synthetic biodegradable polymer meshes have been hybridized with collagen sponge to combine their advantages to form a new kind of hybrid mesh. The hybridization was achieved by forming collagen sponges between the interstices of synthetic biodegradable polymer mesh. SEM observation indicates that collagen microsponges with interconnected microporous structures were formed in the interstices of the synthetic polymer mesh (Figure 2). The polymer mesh was embedded in the collagen sponge sheet so that the fiber bundles of polymer mesh and the collagen sponges were alternately chained.

From these results, it can be concluded that the polymer sponge, or mesh serving as a skeleton, reinforced the hybrid scaffolds and resulted in easy handling, while the collagen sponge provided the hybrids with a microporous structure and hydrophilicity, and therefore, easy cell seeding. These hybrid scaffolds could be useful for tissue engineering.

3. Application of the hybrid scaffolds for tissue engineering of bovine articular cartilage. [7]

The hybrid sponge of PLGA and collagen was used as the porous scaffold for tissue engineering of articular cartilage with PLGA sponge and collagen sponge used as the controls.[7] Bovine chondrocytes were isolated from the shoulder articular joints of a calf, seeded in biodegradable porous polymer scaffolds, and implanted subcutaneously in the dorsum of athymic nude mice to tissue engineer articular cartilage in vivo. Chondrocytes were seeded in low (1×10^7 cells/mL) and high (5×10^7 cells/mL) densities and cultured in culture medium under a 5% CO_2 atmosphere at 37℃. The cell seeding in the collagen sponge and PLGA-collagen hybrid sponge was easy, but cell seeding in the PLGA sponge required prewetting of the sponge. In addition, more cells adhered to the PLGA-collagen hybrid sponge than to the PLGA sponge. The hybridization of the PLGA sponge with the collagen improved its hydrophilicity and thus facilitated cell seeding.

Histological examination of these specimens using hematoxylin and eosin stains revealed that the percent of chondrocytes in their natural round morphology increased with an increase in the implantation period in the implants seeded with chondrocytes. A greater number of round morphological chondrocytes were observed in the PLGA-collagen hybrid sponge and the collagen sponge than in the PLGA sponge. A decrease of neovascularization was also noted with increased implantation time. In the PLGA-collagen hybrid sponge not seeded with chondrocytes, only fibroblasts and a high degree of neovascularization were observed.

4. Conclusion

Many biodegradable biomaterials have been used and fabricated into various shapes for tissue engineering. These scaffolds showed promising results, guiding tissue development. The processing of the chosen materials into appropriate three-dimensional scaffolds with desired shapes and pore structures will be critical. Although the porous three-dimensional scaffolds possess interconnected highly porous structures, development of scaffolds allowing easy cell seeding and spatially even distribution of transplanted cells remains to be challenged. The concept of combining synthetic polymers with naturally derived polymers and hydroxyapatite is very attractive and seems effective. The skeleton of synthetic polymers defines the gross shape and size of the engineered tissue and supports the forming tissue during the initial stages, while the embedded collagen sponge or collagen-hydroxyapatite sponge facilitates cell invasion and growth. Hybrid scaffolds possess the favourable properties of synthetic polymers, naturally derived polymers and hydroxyapatite. By using PLGA-collagen hybrid sponge as the scaffold, tissue engineered cartilage with a defined shape was developed.

References

1) Langer R, Vacanti JP. Tissue engineering. Science 1993;260:920-926.
2) Nerem RM, Sambanis A. Tissue engineering: From biology to biological substitutes. Tissue Eng 1995;1:3-13.
3) Chen G, Ushida T, Tateishi T. Preparation of poly(L-lactic acid) and poly(DL-lactic-co-glycolic acid) foams by use of ice microparticulates. Biomaterials 2001;22:2563-2567.
4) Chen G, Ushida T, Tateishi T. Fabrication of PLGA-Collagen Hybrid Sponge. Chem. Lett. 1999; 561-562.
5) Chen G, Ushida T, Tateishi T. Hybrid Biomaterials for Tissue Engineering: A Preparative Method of PLA or PLGA-Collagen Hybrid Sponge. Adv. Mater. 2000;12:455-457.
6) Chen G, Ushida T, Tateishi T. A biodegradable hybrid sponge nested with collagen microsponges. J. Biomed. Mater. Res. 2000;51:273-279.
7) Takashi Sato, Guoping Chen, Takashi Ushida, Tomoo Ishii, Naoyuki Ochiai, and Tetsuya Tateishi. Tissue engineered cartilage by in vivo culturing of chondrocytes in PLGA-collagen hybrid sponge. Materials Science & Engineering C 2001;17:83-99.

JSME News Vol. 13 No. 1

Editors:Ken Okazaki,Marie Oshima,
Masafumi Katsuta,Yukio Yamada
International Activities Committee
Published by The Japan Society of Mechanical Engineers
Shinanomachi-Rengakan Bldg,Shinanomachi 35,
Shinjuku-ku,Tokyo 160-0016, Japan

Fax:81-3-5360-3508

URL http://www.jsme.or.jp/English