Understanding of Healthcare Design

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Abstract Healthcare industry scope grows quickly due to the serious aging problems and the concerns towards health and well-being life increasing continuity. The peoples' recognition towards healthcare is not limited on the life extending; they pay more attention to how to ensure and develop normal functioning of a living organism, how to enjoy the whole process and so on. Therefore, the demand for health-related products and services increases. Recently, many domestic, foreign enterprises and related research institutes do a lot of researches about healthcare and healthcare design, but the data or research about overall understanding of healthcare-related classification and different design methods to be used in the each healthcare part is not enough and clear, so the basic study to help understanding healthcare and healthcare design, with the diverse social issues and developing trends as the base, is very necessary.In this study, classified the healthcare field by existing activities and issues about healthcare, and analysis each part develop and design direction, as well as design method. And took two examples to explain the healthcare design more clearly, one is healthy city design which is design for public healthy people and the other is case study about new mass customization service process model for the artificial knee joint, which is the case study design for unhealthy people by applying with service design method.From the two case study we could see the relationship between service design. The study for healthcare design is only a starting, under the interventions of multidisciplinary, the study are and study method of healthcare design will be more diversification. By importing service design method into the healthcare design industry could form a completely circle and improve the quality of healthcare industry.

Key words Healthcare, Healthcare Design, and Service

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1. Introduction

The elderly population above 65s will reach to16-22% in the developed countries in 2020; this ratio in Korea was 10.7% in 2009, and predict to increase to 14.3% in 2018, 20.8% in 2026. Health care industry is one of the world's largest and fastest-growing industries. Consuming over 10 percent of gross domestic product in most developed nations, health care can form an enormous part of a country's economy. The scale of Healthcare industry is predicted to be 2.3 times of IT market, which the world market scale will be 3 trillion 2 hundred billion dollars. For United States, the health share of gross domestic product (GDP) is expected to hold steady in 2006 before resuming its historical upward trend, reaching 19.6 percent of GDP by 2016(Health Affairs 26, No.2 (2007)). By this serious aging problems and rapid market growth, healthcare design becomes hottest topic at the present day. But how could we, be as designers to get approach to it, how could we catch it?

1.1 Healthcare

Healthcare is the diagnosis, treatment and prevention of disease, illness, injury, and other physical and mental impairments and so on in humans. Healthcare is also a rapidly evolving industry where firms face constantly changing conditions and an ever-increasing demand for services. While the definitions of the various types of healthcare vary depending on the different cultural, political, organizational and disciplinary perspectives, there appears to be some consensus that primary care constitutes the first element of a continuing health care process, that may also include the provision of secondary and tertiary levels of care. It could be classified into 3 big categories by its 3 different functions: preventing from disease, treatment and health keeping. Each of them has their own related area depending on the era.

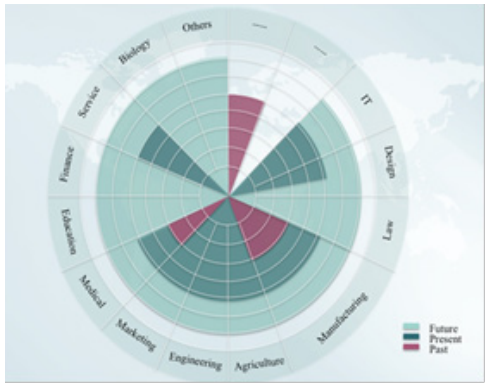

Fig. 1 Healthcare in Different Era

Fig. 2 Healthcare and Supported Disciplines

Today, with the growing of technology rapidly, is no longer confines the field of healthcare to simple disease treatments and pharmaceuticals, but evolves into an integrated area by the reliance on Engineering, Medicine, Services, Marketing, IT technologies and so on; and on this base, a variety of new industrial forms shows up.

With the supporting of various technologies cooperation, healthcare industry becoming more and more prosperous in recent years, and a lot of new healthcare forms come thick and fast. And these new forms are omnipresent and have affinity with our daily life, such as Health Food, Household support/service security, Tele-health management and so on. During the collecting process, we saw the multiformity of healthcare contents. Then following the attributes of each content, they could be grouped as self-cure market, self-care market sport market, healthcare tourism, wellness market, cure business support market, hospital market etc. By selecting for weak people- for healthy people as the horizontal axis, for individual- for business as the vertical axis, and all the healthcare items as the contents, drew the healthcare area chart.

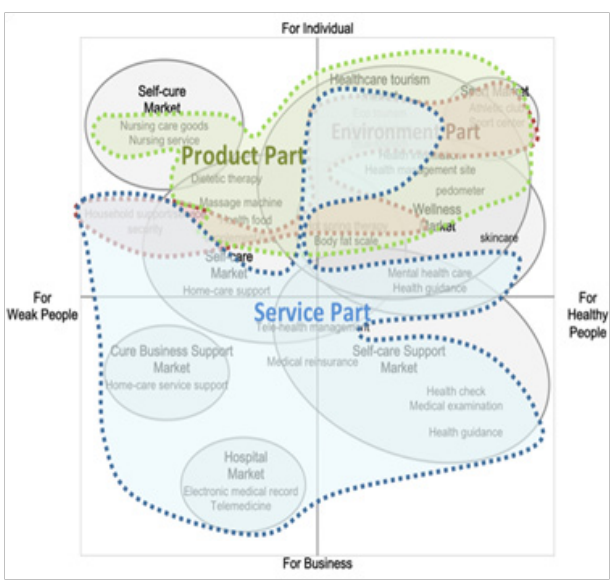

Fig. 3 Design Points for Healthcare Contents

And due to the different attributes, the contents have their own focusing point for design, for example, for home-care support service should be the backing(here the service part means the service simply)

1.2 Healthcare Design & Service Design

As we known, service design is an activity of planning and organizing people, infrastructure, communication and material components of a service in order to improve its quality and the interaction between service provider and customers. To stay competitive and survive the changes organizations are presently facing, they need to reassess the way they are structured, function and build relationship with consumers. Service design provides us with useful methods and tools to bridge the gap between the social reality and design, which means could it really a design that systematic, sustainable and most important is people-centered.

The growth of Healthcare design combining with the high technology and various disciplines shows a strong growing momentum. Service design could be a good way to balance development in healthcare area.

Service design business model is B to B, but with the people- centered as the design starting and also the design final purpose; and the healthcare design business model seems like B to C mostly, it means the most output of high technology serves to consumers directly. So by importing service design method into the healthcare design industry could form a completely circle and improve the quality of healthcare industry.

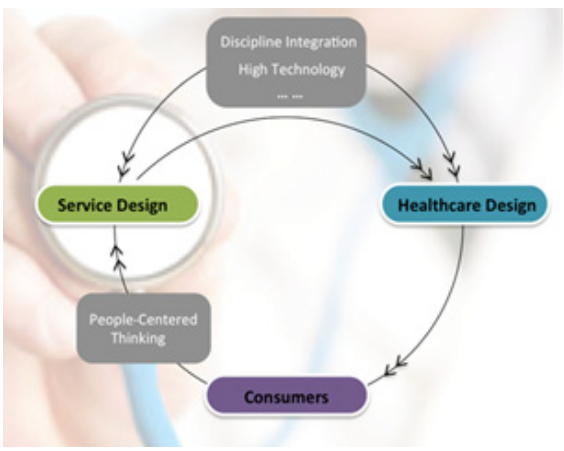

Fig. 4 Healthcare Design & Service Design

2. Method

Here the author will show two case study for explaining healthcare design clearly, one is healthy city design case that design for healthy people; the other is New Mass Customization Service Process Model

for Artificial Knee Joint,.

2.1 Case Study on Healthy City Design

Outdoor healthcare public utilities are paid more and more attention due to the increasing focus on people's health. Based on the preliminary statistics, world's healthcare market has invested as much as 927 trillion dollars and it has an immense market resource and developing potential. Therefore, in order to adapt to the changes of the global market and to establish a future healthy living environment, the major developed countries in the world have put healthcare as the new motive power for the development of cities and made positive exploitation and investment, especially in areas such as city design. But so far, all kinds of cities' design and public design focus on the exploitation of the beauty of cities , concentrating on the city appearance and visual effect. Today, the vitality of city design has to be insured so as to improve the competency of design in a time in which healthcare is being extremely cared about. It is necessary to blend design with the new healthcare industry and exploit an energetic healthy city.

Table 1 The Differences between Health City and Normal City

	Existent City Design	Health City Design
Subject	Focus on Citizen and Resident	Focus on Citizen and Resident
Plan	Construct Remarkable city	Construct Healthy City and City Space
Form	Emphasized convenient usage	Emphasized healthy and lively city space
Function	Same using purpose	Differences depend on different installation
Service	Emphasized convenient and comfortable usage	Living support related health all the time
Citizen Health	Activities besides Public installation	Provide place and health activities

2.1.1 Research Necessity& Objective& Research Method

The aim to built Healthy City is to establish a new and effective way to clear up all kinds of factors which may threaten people's health in the city life. It can guide people to choose healthy life and then lead the health life and Healthy City System to come true.

The city environment is the carrier of the Healthy City Design. On the one hand, it can guide people daily life by supporting healthy news at anytime, anywhere. On the other hand, In the healthy design, we

have to target to improve city environment and facilities. It can guide people to increase activities efficiently. Through the two sides, we can establish a Healthy City guideline.

screened out the important indicators of establishing healthy city through combining the social area analysis theory with the main determinants of health and city indicators; divided these indicators into both spiritual and physical features; and carried out empirical studies on these two groups of features respectively.

As for psychological feature part, happiness index test and environmental psychology test have been conducted. Healthy city guideline has been established in terms of the physical features part. And feasible survey has been conducted in Jeuoju in Korea and Beijing in China.

2.1.2 Healthy City Indicators Extract

Screened out the important indicators of establishing healthy city through combining the social area analysis theory with the main determinants of health and city indicators; divided these indicators into both spiritual and physical features; and carried out empirical studies on these two groups of features respectively.

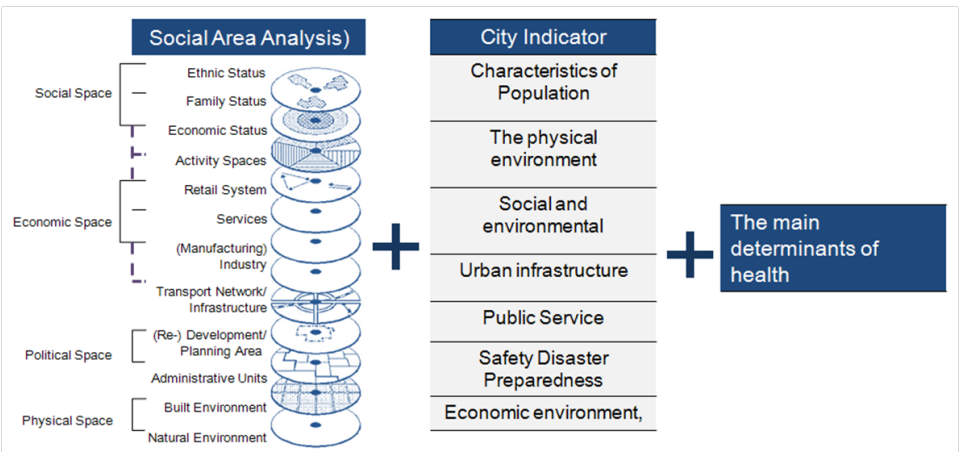

Fig. 5 Indicators collected

2.1.3 Sample Research

Psychological test and physical test about health city was underway.

The test average about healthy city in both environment psychological tests and happiness index tests are higher than general

urban city, which could prove the feasibility of health city. After the Physical Test, all the guideline was verified in Jonju and Beijing

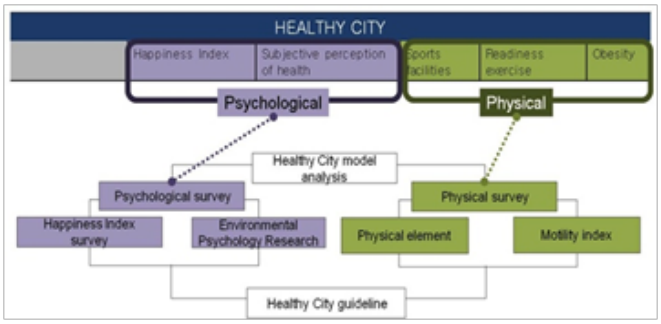

Fig. 6 Indicators collected

Fig. 7 Guideline Classification

2.1.4 Findings

Firstly, important indicators of establishing healthy city have been displayed.

Secondly, the importance of healthy city has been proved through the psychological test, and laid theoretical foundation for establishing healthy city system.

Thirdly, healthy city guideline has been established and proved feasible though field investigation.

2.2 Case Study about New Mass Customization Service Process Model– for the Artificial Knee Joint

Mass customization is a kind of overall revolutionary business strategy and mode, which is the systematic considerations of the whole process of product R&D, production, distribution and sales as well as the whole process from product selection, purchase to acceptance of the customers.

First, necessity for module development and decoupling. The following contents discuss the cases of diversified mode through improving effectiveness of decoupling at each stage and illustration the combination of diversified module and basic platform

Second, combination of modules. The combination of Modules mainly emphasizes two significances. First, harmonize the difference of culture and Context correctly, and improve efficiency and economy commodity Line up through commodities with good combination. Second, delivering the selection of Module to customers is the real

MC. Under such circumstance, consider who generates what at which place. In addition, consider the inventory management (including site, etc.) for rapid response.

2.2.1 Core Contents of the Research

Personalized artificial knee joint is mainly reflected in its surface, because the surface of each patient's knee is in different shape and size, so the artificial knee joint surface used for patients are different in sizes and shapes. Artificial knee joints are made of metal and high density plastic materials based on the structure, shape and function of human joints. The types of metal include Titanium, cobalt-chromium alloy, cobalt-chromium-molybdenum alloy and stainless steel, etc. The plastic materials are generally wear-resistant high density and ultra-high molecular weight polyethylene (UHMWPE).

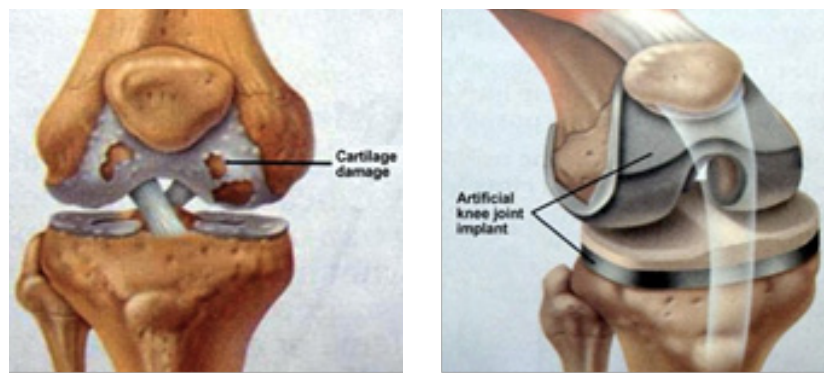

Fig. 8 Lesions of the Knee and After Knee Replacement

2.2.2. Decomposition of Artificial Knee Joint

In order to abstract the mutually compatible product elements, carryout decomposition of all the investigated implants to decompose them into multiple items. The investigated implants are divided into three components and decomposed to 25 items in total. Then organize according to the selection and classification of 25 items by the doctor to obtain the function related items and dimension related items. There are 3parts in the function related items, femur condyle, insert and tibia plateau. The femur condyle part include femur condyle radius, M/L radius, patella sliding track, back-end slope, box available, symmetrical, front-end shape, limit and return device and patella trajectory expand

bending angle, 9 items in total. The insert part includes A/P height difference of insert, insert curve, bump of insert and locking structure, 4 items in total. The tibia plateau part includes anti-rotation, structure of tibia plateau, the top surface treatment and the bottom surface treatment, 3 items in total. The organization of dimensions items include 3parts also, femur condyle, insert and tibia plateau. The femur condyle part includes A/P diameter, L/R diameter, front-end height and gender differences, 4 items in total. The insert part includes insert A/P diameter, insert L/R diameter and insert height, 3 items in total. The tibia plateau part includes A/P diameter and L/P diameter, 2items in total.

2.2.3. Import of Mold Functional Combination

In order to obtain the mutually compatible item combination from the function group, carry out discussion with engineers on the related function groups to obtain the mutually compatible item combination as shown in Figure 9 and 10

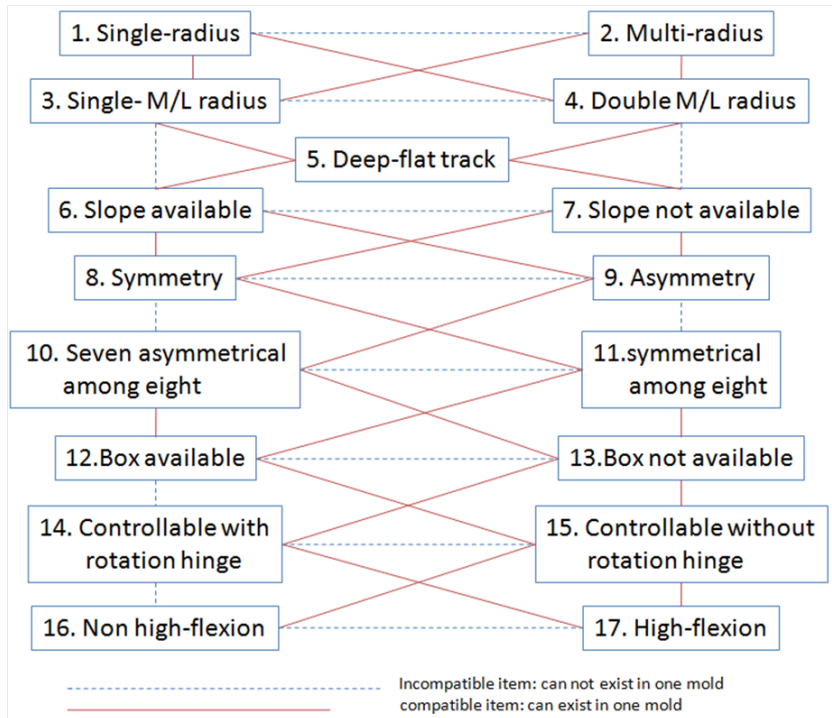

Fig. 9 Functional Combination Proposed by Engineers

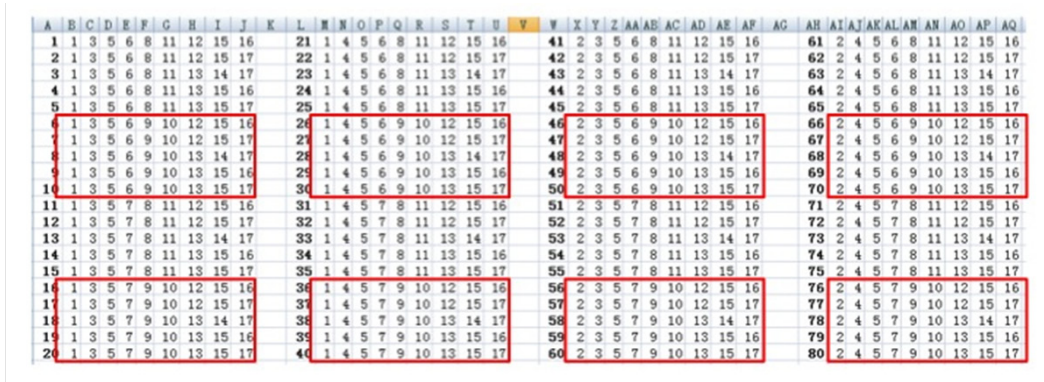

Fig. 10 Final Functional Combination Proposed by Doctors

2.2.4.Measurement for Human Knee Joint

In order to carry out actual measurement for human knee joint, the author spent three months collecting CT data in three hospitals in Beijing from 310 patients in total. The collection covers patients in the three hospitals from 1994 to 2005. Through measurement for CT images, the final useful data include 162. The final data measurement is shown in Figure 11

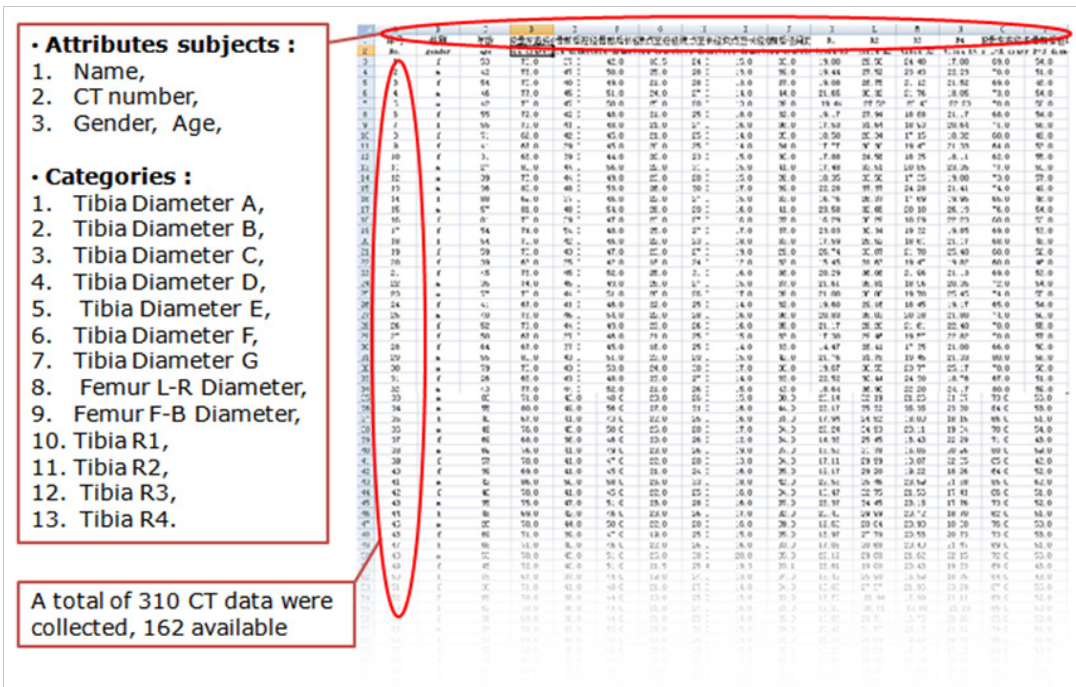

Fig. 11 Measurement Data for Knee Joint

The dimension items of measurement part are shown in Fig12, Fig.13 and Fig.14, 13 items in total, including: 1. Width (distance

from Point 1 to Point 2); 2. Short length (distance from Point 3 to Point 4); 3.Long length (distance from Point 5 to Point 6); 4. Distance from Point 3 to Point 7; 5. Distance from Point 5 to Point 8; 6. Distance from Point 2 to Point 7; 7.Distance from Point 7 to Point 8; 8.R1 (Arc radius from Point 2 to Point 3); 9.R2 (Arc radius from Point 1 to Point 5); 10.R3 (Arc radius from Point 2 to Point 4); 11.R4 (Arc radius from Point 1 to Point 6); 12.Femoral Distal Width; 13.Femoral Distal Length.

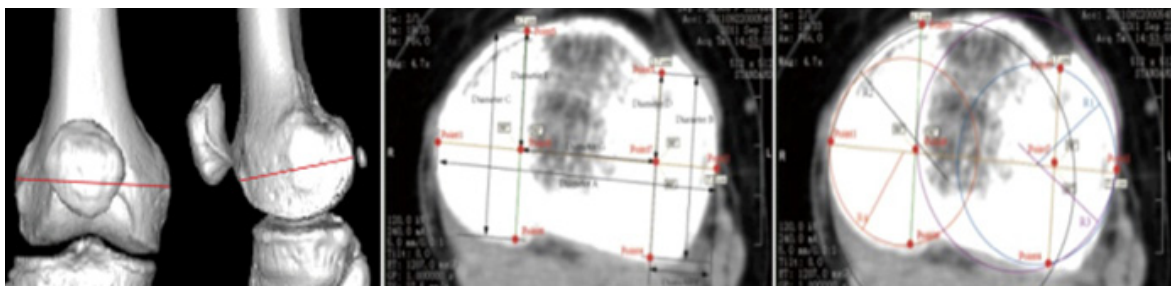

Fig. 12 Femoral Distal Length and Width Fig.13 Tibia Measurement Item AFig.14 Tibia Measurement Item B

2.2.5. The result of PCA and New process proposal

1. Through PCA, the following result can be obtained as shown in Table 2

2. Find out the value with maximum absolute in each inherent item in the data of 10 principal components corresponding to each inherent item. In the first inherent item Tibia Diameter A, the absolute value of principle component 9 is the maximum, so select this value. In the second inherent item Tibia Diameter B, the absolute of principle component 7 is the maximum, so select the value. In the 3rd inherent item Tibia Diameter C, the absolute value of principle component 6 is the maximum, so select this value. In the 4th inherent item Tibia Diameter D, the absolute value of principle component 8 is the maximum, so select this value. In the 5th inherent item Tibia Diameter E, the absolute value of principle component 10 is the maximum, so select this value. And so on, select the principal components with maximum absolutes corresponding to 13 inherent items.

Table 2 Measurement Data for Knee Joint

Intrinsic value number	Intrinsic value	Coverage	Accumulation
principal component No.1	103.4730911	63.36%	63.36%
principal component No.2	15.23089218	9.33%	72.69%
principal component No.3	8.220410347	5.03%	77.72%
principal component No.4	7.226947308	4.43%	82.15%
principal component No.5	6.836411476	4.19%	86.34%
principal component No.6	5.970814228	3.66%	89.99%
principal component No.7	5.321860313	3.26%	93.25%
principal component No.8	3.032555819	1.86%	95.11%
principal component No.9	2.27395606	1.39%	96.50%
principal component No.10	2.092424154	1.28%	97.78%
principal component No.11	1.887688041	1.16%	98.94%
principal component No.12	1.097430229	0.67%	99.61%
principal component No.13	0.636974335	0.39%	100.00%

The meanings of the values after selection are as follows: If the selected value is positive, it is in direct proportion with the principal component. If the selected value is negative, it is in inverse proportion with the principal component. In other word, if the principal component and selected value are positive, the value is large when the principal component is positive and the value is small when the principal component is negative. If one of the principal component and selected value is positive and the other is negative, the value is small when the principal component is positive.

3. Visit the doctor and acquire the allowable tolerance range of the inherent items.

After PCA analysis, the opinion from the doctor appears very important. The doctor has made suggestions on tolerance of 13 attributes: Tolerance of Attribute No.1 is 5mm, tolerance of Attribute No.2 is 3mm, tolerance of Attribute No.12 is 4mm and tolerance of Attribute No. 13 is 5mm. The tolerances of remaining No. 3, 4, 5, 6, 7, 8, 9, 10 and 11 are not available. The doctor believes that the tolerances of Attribute No.8 and No.9 are important, which were never observed before. At the same time, the producer also believes Attribute No.8 is the important attribute.

60mm(57-62mm), 65mm(62-67mm), 70mm(67-72mm), 75mm(72-77mm), 80mm(77-82mm), 85mm(82-87mm), 6 levels in total. The length is divided into 35mm (35-38mm), 38mm (38-41mm), 41mm (41-44mm), 44mm (41-47mm), 47mm (47-50mm), 50mm (50-54mm), 54mm(54-60mm), 7 levels in total. (Shown as Bellow)

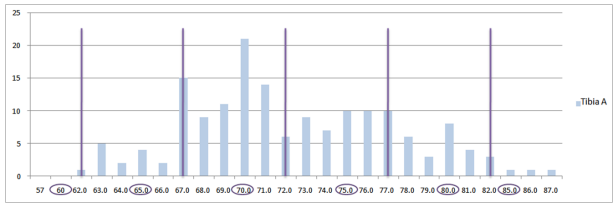

Fig. 15 Tibia A (M/L) Classification

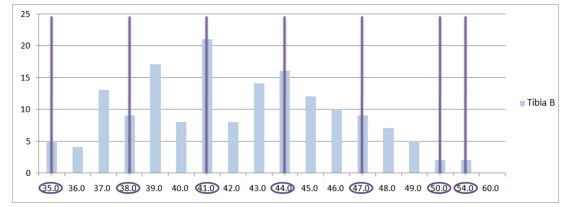

Fig. 16 Tibia B (A/P) Classification

According to the advices of doctors, 9 levels in total. The width is 55-86mm based on classification by every 5mm, 55mm(55-60mm), 60mm(60-65mm), 65mm(65-70mm), 70mm(70-75mm), 75mm(75-80mm), 80mm(80-86mm), 6 levels in total. (Shown as Figure 23-24)

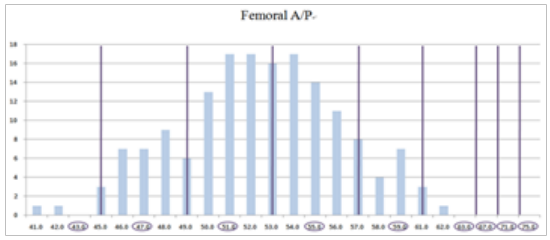

Fig.17 Femoral Candyle A/P Classification

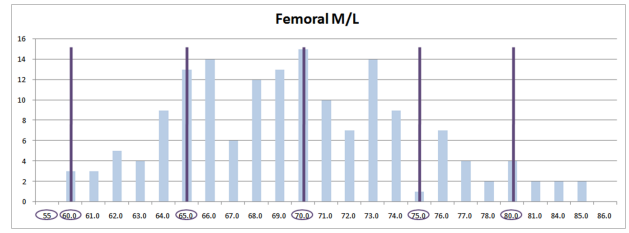

Fig. 18 Femoral Candyle M/L Classification

Comprehensive review at classification before:

As shown: Tibia M/L diameter: 60mm (57-62mm), 65mm (62-67mm), 70mm (67-72mm), 75mm (72-77mm), 80mm (77-82mm), 85mm (82-87mm), Tibia A/P diameter: 35mm(35-38mm), 38mm(38-41mm), 41mm(41-44mm), 44mm(41-47mm), 47mm(47-50mm), 50mm(50-54mm), Femoral candyle A/P diameter: 43mm (41-45mm), 47mm (45-49mm), 51mm (49-53mm), 55mm (53-57mm), 59mm (57-61mm), 63mm (61-65mm), 67mm (65-69mm), 71mm (69-73mm), 75mm (73-76mm), Femoral candyle M/L diameter: 55mm (55-60mm), 60mm (60-65mm), 65mm (65-70mm), 70mm (70-75mm), 75mm (75-80mm), 80mm (80-86mm).

The above discusses the classification of attributes of tolerance offered

by the doctor. The doctor cannot offer the tolerance of the remaining attributes but these attributes also have significance to description of prostheses form. Especially the Attribute No.8 should be the item to be focused on that is proposed by the doctors and engineers, whose tolerance is available under current technical conditions. This means that the tolerance may be large as 5or 10. Maybe all persons only require one model with all the conditions satisfied. Of course, the tolerance may be others. Under the current technical conditions, the description and control of these attribute tolerance cannot be realized. However, these attributes should be considered under allowable technology in the future.

2.2.6. Research Result and New Flow Proposal

The previous flow is improved with adoption of function models and dimension models.

The patients obtain the diagnosis of the doctor after CT or MRI examinations. Once the operation is determined, confirm the operation scheme and prostheses scheme required for the patient, then select the required functions in function models. The production enterprise will find out the corresponding function model number according to the prostheses function required by the doctor. At the same time, obtain the accurate tibia data for dimension model through CT or MRI examination of the patient and the femur dimension obtained can be directly used for function model and further casting. In this way, the implants obtained by machining according to the accurate data of the patient match the conditions of the patients and satisfy the function requirements by the doctor. After machining, carry out carving, cleaning, packaging, aseptic treatment, and transportation until final operation.

2.2.7. Effect of New MC Flow Proposal

The products produced in the lineup mode by the producers in the standard form cannot satisfy the requirements of the doctors and patients. Through MC models, the producers can fully satisfy the requirements of individual treatment content according to the order from the doctors and patients. Such production can reduce the waste

and risk compared with the previous production process, thus to make the production more efficient and the products supplied to the patients more accurately. Such improvement is the method that is helpful to the producers and patients. The Fig 19 below shows the time, cost and payment required at each stage of the production.

Producer payment Patient payment

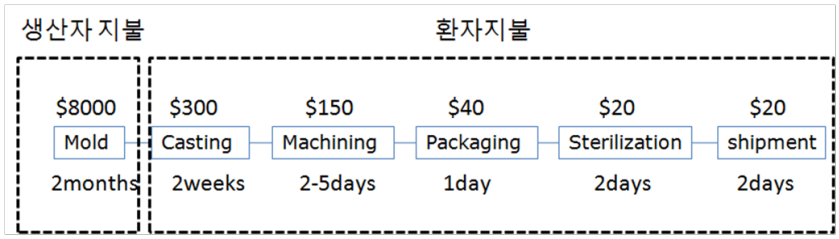

Fig.19 Producers and Patients at Each Stage

Among patient, doctor and manufacture, each role has mutually correlated interest or focus, which should also have positive and negative impacts on each role. In this new flow, the benefits to patient are matching of function and size more fit to, to reduce pain, to reduce dangerous, to increase the success rate of surgery, to increase the use time of the implant. The challenges are to pay in advance, to increase payment, to need waiting time. The benefits to the doctor are to increase the success rate of surgery, to reduce the time of surgery, toe reduce the rate of renovation. The challenges are to need accurate surgery, to need the education and training of new technology. The benefits to the manufacture are high production efficiency, low investment, reducing the economic risk. The challenges are to need high-tech, to need accurate transmission, to need developing tools.

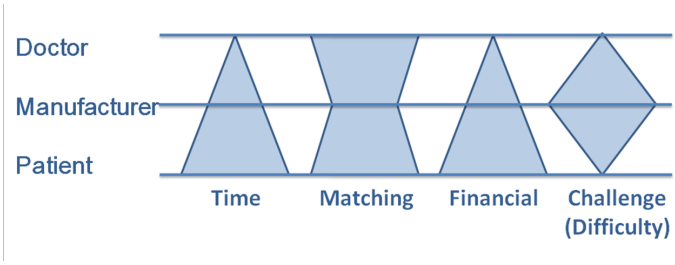

Fig.20 Advantages and Disadvantages Comparison of Time, Matching, Economy and Challenging

2.2.7 Findings and Future Research

The research has obtained 40 models suggestions in the functional models and four groups of classification suggestions in dimensional models to supplement the previous research from the perspective of sex, race, age, etc. As for further research in the future, it can focus on the following aspects.

1. The previous research has offered suggestions on customization and production between function models and dimension models; how to more efficiently combine both can be emphasized in the future research. The previous research has obtained suggestions on four groups of classification of four attributes in dimension models. In addition, two attribute doctors and engineers believe the attributes are important but cannot offer accurate tolerances. If technical conditions permit, the tolerances of these attributes must be the parameters to be considered. At the same time, the mutual relations of four groups of classification should also be considered.

2. The study introduces the method and flow of improving mass customization production of the medical productions. After the more professional measurement for the human body by medical professionals, as well as collection, adjustment, perfection and clinic practice upon the opinions from R&D department and mechanical engineers, the specific solutions that are more suitable to the users should be perfected though the analysis and research mentioned in this study.

3. Conclusion

The study for healthcare design is only a starting, under the interventions of multidisciplinary, the study are and study method of healthcare design will be more diversification. By importing service design method into the healthcare design industry could form a completely circle and improve the quality of healthcare industry.

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