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R&D Management issues for small to medium sized technology oriented manufacturing firms

– A case of material development for dental application

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Abstract This paper discusses R&D strategy for a small to medium sized technology oriented manufacturing firm. Specifically, issues to catch up the top runner and to establish competitive advantage will be discussed based on a case study of Yamamoto Precious Metal Company Ltd. This company was originally established as a retailer of gold material more than 55 years ago, but it changed its business model to manufacturing company. Major businesses were refinement and processing of precious metals and production of precious-metals alloy for dental application. In accordance with market requirement changes, the company expanded the product portfolio to ceramics, and resin material keeping the application domain same. The company was late to deal with composite resin which is popular material used in dentists. The composite resin system is composed of main body and interface to the tooth. Existing players provide the main body and the interface separately. Typically the interface material is profitable as opposed to the main body. In order to get in this business, Yamamoto Precious Company is developing unified material to integrate two parts. This will reduce dentists' burden tremendously at the cost of profitability for the manufacturer. The R&D strategy which can be categorized as a destructive innovation will be discussed.

I. INTRODUCTION

Larry Greiner discussed growth of corporation and proposed the "five phases of corporate growth" focusing on management style [1]. Clearly, a company grows coping with change of various outside environments, and the growth of business is not only attained by the interaction of the person in an organization. The outside environment which surrounds a company changes suddenly and frequently. In order to respond to such change of outside environment, a company has to market a new product and new technology, continuously.

Vernon Ehlers defined "Valley of Death" as a situation where developed product cannot be commercialized by shortage of management resources. Branscomb and others define "the Darwinian Sea" as the severe transition process between invention and innovation [2]. It is difficult to pass through the Darwinian Sea for small to medium sized manufacturing firms, because they do not have sufficient management resources. However, they can overcome the barrier by cooperating with universities, acquiring outside tacit knowledge, and getting complement technology required for product commercialization.

II. OBJECTIVES

This paper discusses issues in development of hard resin for crowns and development strategy of composite resin for dentistry filling which is under development now in Yamamoto Precious Metal co., Ltd. These materials are for medical application and there are many legal regulations for commercialization. Based on analysis of the case, an R&D model for small to medium sized technology oriented manufacturing firm to reduces the risk of commercialization and to grow coping with change of outside environment, will be discussed.

III. SITUATION OF DENTAL CARE AND DENTAL MATERIAL INDUSTRY

It is estimated that aged population in Japan is to be about 35 million in 2025 [3]. Development of the medical device industry is strongly required in the super-aged society. However, it is difficult, especially for a small to medium sized technology oriented manufacturing firm, to enter the medical device industry because of substantial barrier both in technology and legal issues. A small to medium sized firm lacks talents, facilities, funds and information. It is realistically difficult to enter and even if it does, it is hard to have competitive advantages.

3-1 Issues if the dental industry

Fig. 1 shows the number of people who are engaged in dental business. There are currently about 66,000 dentistry clinics in present Japan.

Number of dentists increases by 3000 people every year. and it resulted in surplus dentists in especially urban areas [3]. In connection with it, price competition of medical treatment and the deterioration of quality in medical care are pointed out. Since the dental care fee in connection with dentist's income has not changed for the past 15 years, the dentist per capita income is decreasing. On the other hand, there are groups of dentists with extremely high income, who provide cutting edge dental service like dental implants.

Moreover, there is also a problem in the environment of dental technician who fabricates prosthetic appliance. Joint efforts between dentists and dental technician to provide dental service for the clients is ideal, but dental technician plays a role as a subcontractor in reality. It causes price of prosthesis to fall down and working condition of dental technician is getting worse. As a result, turnover of young dental technicians is increasing and it causes aging issues in prosthetic business.

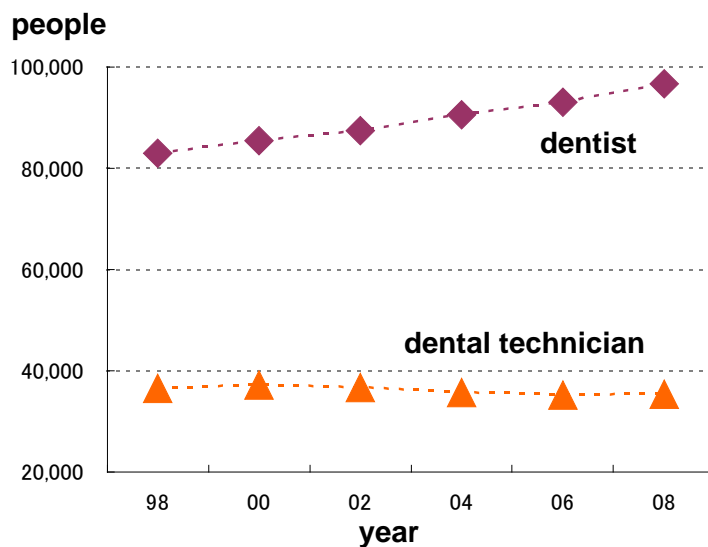


Fig.1 Number of dental personnel [3]

3-2 The state of the dental material industry

Fig. 2 shows size of dental material market from year 2003 to year 2008 [4]. The market size seems to increase year by year. However, it is due to market price of precious metal, and the dental material market itself is not actually growing.

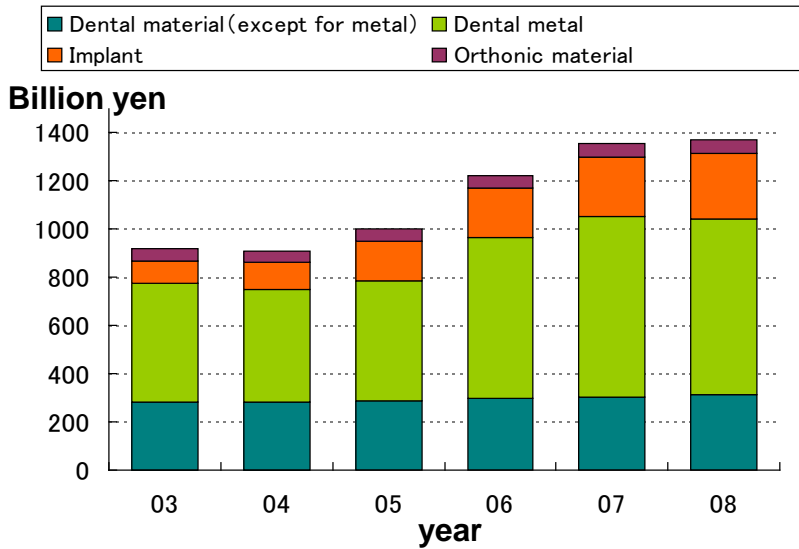


Fig. 2 Market trend of dental material [4]

IV. CASE STUDY OF YAMAMOTO PRECIOUS METAL Co., LTD.

4-1 The corporate history

Yamamoto Precious Metal Co., Ltd. is a technology-oriented small to medium sized manufacturing company. It was founded 55 years ago. The company history can be divided into three phases with different strategy.

i) Phase 1: period from startup to the first crisis due to environment change

Yamamoto shop, the forerunner of Yamamoto precious metal, was founded in 1957. The business model was to stock a bulk gold from a dealer and cut down to a bit and sell. In 1976 Yamamoto shop changed organization to YAMAMOTO PRECIOUS METAL Co., Ltd. and decided to concentrate on production technology of melting, rolling and cutting process in addition to retail business. Gold distribution control was deregulated in 1978, which broke down the gold distribution system completely. The market price suddenly rose threefold, and YAMAMOTO PRECIOUS METAL Co., Ltd. faced the crisis of bankruptcy.

ii) Phase 2: change of physical business domain

In order to overcome the crisis of breaking business, the top management paid attention to precious metals alloy for dental application which is a niche market at the time. The company successfully developed technology and it entered the market as a latecomer. Most of manufacturers fabricated these materials with recognition as a general industrial material. However, the company investigated biological safety issues for patients with a University. The guaranteed biological safety for human body of the material was a very effective competitive advantage to the company. Eventually, YAMAMOTO PRECIOUS METAL Co., Ltd. got the top market share in Japan.

iii) Phase 3: new product development

With change of outside environments such as change of needs, steep price escalation of precious-metals, and reform of legal system, YAMAMOTO PRECIOUS METAL Co., Ltd. had to develop new prosthetic materials in the mouth other than metal. After tremendous research and development efforts, the company marketed prosthesis made of ceramics in 2001 and hard resin for crowns in 2006. Since precious-metals alloy is used for foundation of ceramics and hard resin, it is necessary to understand physical characteristics in the junction area of different materials, such as thermal expansion and strength. The company took advantage of having substantial data on interface characteristics and it was helpful to efficient development. Since YAMAMOTO PRECIOUS METAL Co., Ltd. was known as a precious-metal

alloy company, successful research and development of organic hard resin and inorganic ceramics gave big impact to the industry [5]. Hybrid resin with high strength which does not require metal alloy foundation is also marketed now.

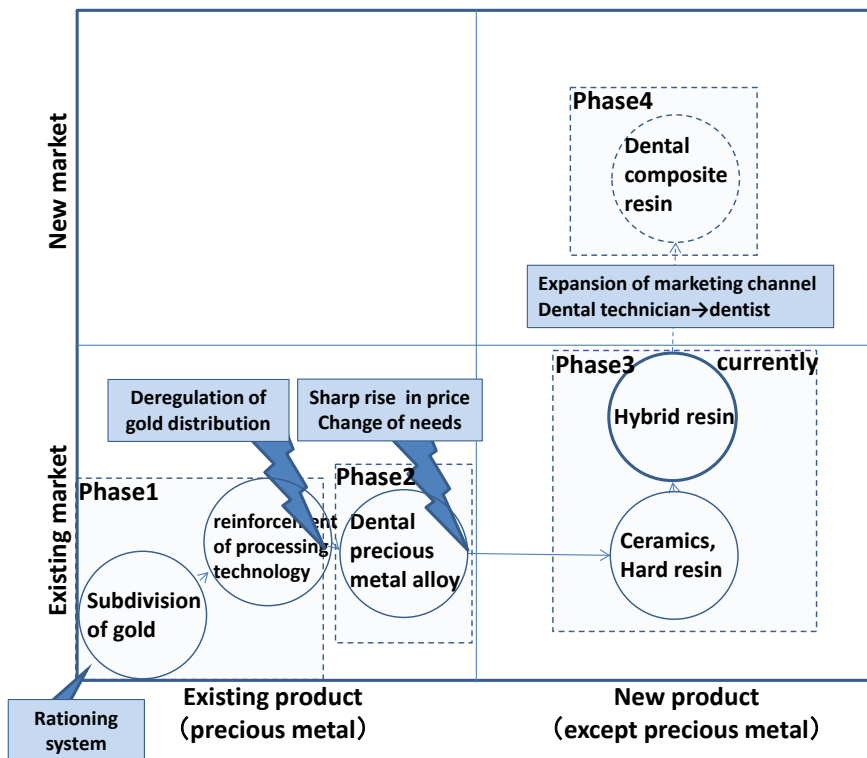


Fig.3 The growth strategy of YAMAMOTO PRECIOUS METAL Co. Ltd.

Specifically, hard resin for crowns was marketed as a latecomer, and got the third position in the market share. It is one of the most popular products in Japan now. Hard resin for crowns is a material used for restoration of dental fracture. Dental technician forms a shape of tooth, stiffening it with visible light of 400nm~500nm wavelength, and a dentist set it to a patient. The base material is methacrylate resin and surface treated inorganic filler was added to the resin for strength improvement. The company started development in collaboration with the University of Tokushima in 1995. Those days, there was neither knowledge nor technical information about hard resin for crowns in the company. The top management could not focus on this project nor put sufficient resources, rather he assigned only one researcher who is in charge. So the researcher utilized R&D resources in university. The development continued in this organization until 1999, and many fundamental data was obtained.

The company hired an engineer who had experience of development at a major company in 1999. He joined the project as a leader. The corporate strategy at the time was to catch up competitors. Experimental evaluation was carried out using a light irradiator which was not standard in the market. So, experimental data was not accurate enough and the device performance was low compared to existing products. Immature fabrication process technology and bad result of test marketing forced the project to be terminated in 2002.

The general manager decided to change the development leader and to put sufficient human resource into the project in 2004. New leader had experience as a dental technician. He was able to evaluate the hard resin material from the view point of application. He resolved the past issues one by one. Finally the new resin product was provided into the market. The product performance was higher than one of competitors, and it created additional market needs.

4-2 Discussion

i) Phase 1

When the company was founded, distribution of the precious metals including gold was controlled by the government. The management utilized the rationing system for gold as an entrepreneur opportunity [5].

ii) Phase 2

In order to grow coping with the change of environment, YAMAMOTO PRECIOUS METAL Co., Ltd. paid attention to the niche market of dental application. It focused on the product biological safety by collaboration with industries and universities. The company exploits a societal trend of rising health concerns as an innovation opportunity.

iii) Phase 3

The success factors of development of hard resin for crowns can be summarized in the following five components.

- The company was in the situation of “no retreat” caused by environment change
- Basic data were able to be obtained from the university even if the company did not have sufficient human resources in the early stages of development.
- The company got an experienced engineer from a major company. Relevant tacit knowledge was transferred by this head hunting.
- A new leader who understands product application was appointed.
- The leader continued years of patient R&D effort with marketing oriented perspective.

There was a variety of barriers which faces the R&D project team. The process of product development of hard resin was a sequence of tasks to get over these obstacles as shown in Fig. 4.

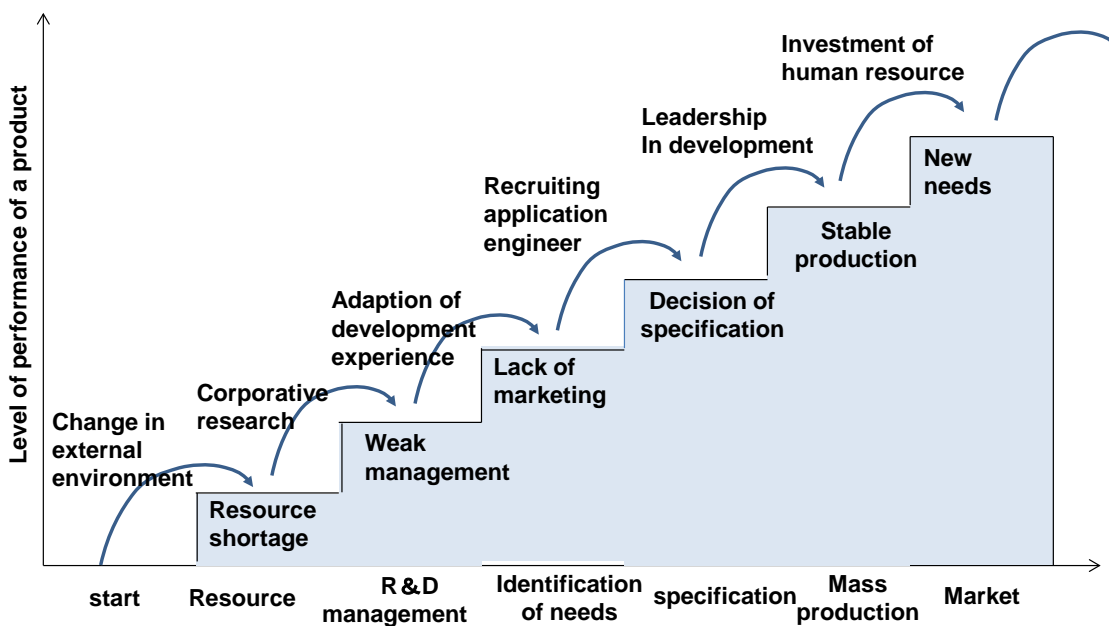


Fig.4 Obstacles and overcoming factors in the process of hard resin business creation

4-3 R&D strategy of new product

YAMAMOTO PRECIOUS METAL Co., Ltd. has produced material for a dental technician, which means that the customer is not a dentist but a dental technician, and market is limited. So, development of dental composite resin for a dentist is new challenge for the company. The company has strong intention

to enter the dental composite resin market, which is maturing, and yet the company is the last entrant. It is significant to make the R&D strategy clear for a small to medium sized technology oriented manufacturing firms to acquire competitive advantage under such conditions.

Dental composite resin is used for filling the cavity which is required medical treatment for esthetical purpose. After cavity preparation, the dentist applies bonding agent to the cavity as an adhesive material. After that, the dentist directly fills the cavity with the composite resin. It is hardened by light irradiation. Dental composite resin has many merits. Quantity of drilled natural tooth is small, and it is not metal allergenic. Medical treatment time is short and inexpensive for health insurance application in Japan. For minimal intervention medical treatment which tries to leave natural tooth as much as possible, keeping the nerve and tooth, dental composite resin is crucial and used by many dentists.

Amalgam restoration which is the medical treatment to fill cavity directly started in France in 1826. Amalgam was the material which contains 50 percent of mercury, and it is not good esthetically since it has metal color. The patient's esthetical demand increased, and silicate cement appeared in 1907. Since silicate cement was white material containing quartz and aluminum oxide, it meets the client's esthetical needs. However, that material had weak strength and desorption issues. In order to solve the issues and pulpitis, a new material was anticipated. Then, organic material, MMA resin, was produced to solve the problem. The MMA resin contains MMA which is the material of acrylic resin, and the product was marketed in 1948. This was immediately hardened after filling, and since handling was very good, it spread in dentist immediately after marketing. However, neither a strength problem nor the problem of pulpitis was solved. Then, the composite resin appeared in 1964, strength and adhesion to tooth, the problem of pulpitis were resolved. It occupied most of the market share [6]. Dental filling material changed from metal to inorganic material and from inorganic material to organic material as shown in Fig.5. MMA resin played a role of a bridge product, and it is considered to have led to development of the present composite resin.

Bonding process has been improved from three steps down to one step. The bonding process in the early stage was constructed by three steps including etching, surface treatment and bonding. Then, the process was simplified to use two liquid at two steps, and the process was reduced to one liquid at one step now. The technology of bonding agent has evolved to simplify dentist's operation.

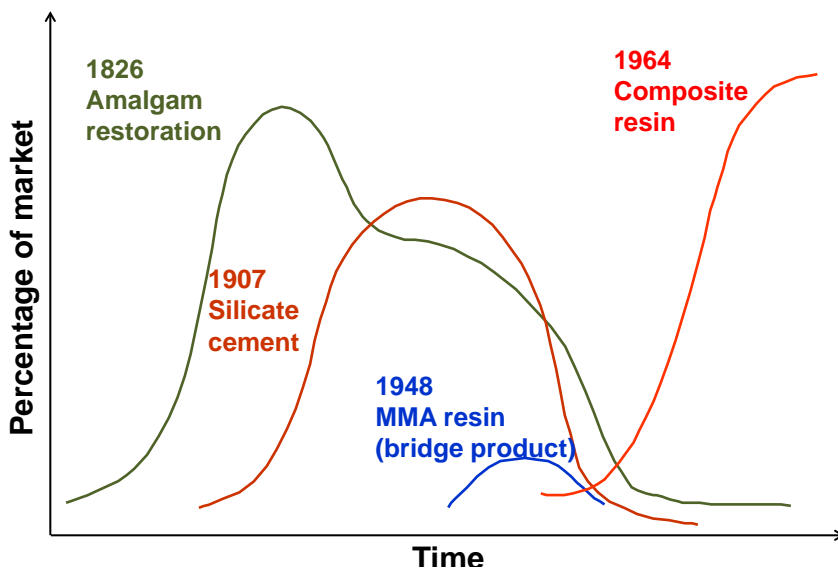


Fig.5 Technologies of dental filling material

The structure of dental composite resin system is composed of main part and interface function. It is common that these parts are implemented separately. In order to get in the market and create a competitive

advantage, the company started development of a new structure. Typically, cost of interface function is low while the price is relatively high resulting good profitability. Moreover, the market size of interface function is large. So, most of composite resin manufacturers have a variety of products lines for such interface function to get profits. In the new structure, however, main part and interface functional part are integrated, and a main unit has the interface function at the same time. The other companies who enjoy big profit from the conventional structure are not easy to market the new product because of less profitability.

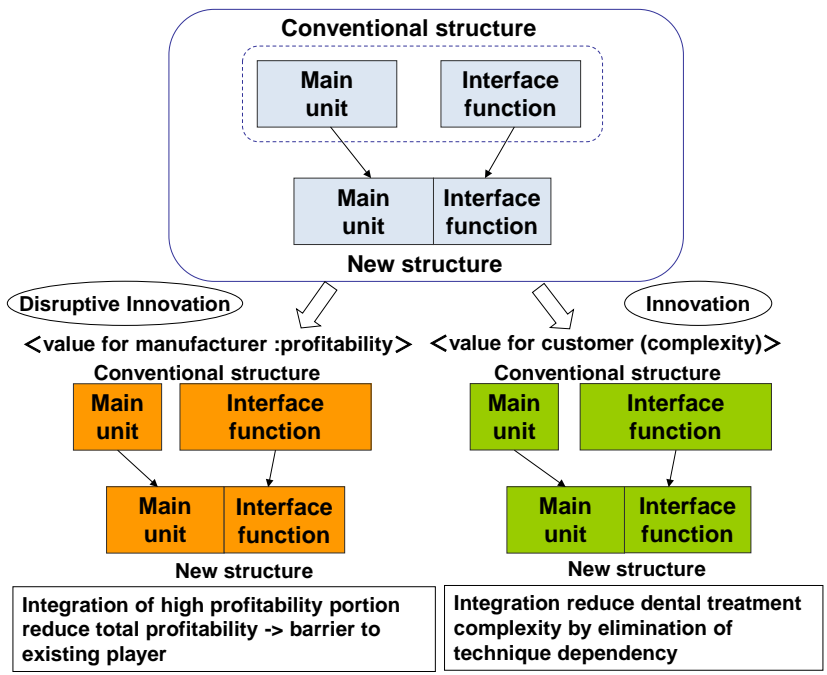


Fig.6 New structure of the dental composite resin

This will provide an opportunity for a small to medium sized manufacturing firm like YAMAMOTO PRECIOUS METAL Co., Ltd to enter the new market. In the conventional structure, performance of interface function depends on tooth surface wetness, quantity of bonding agent, and other technical factors like air blow treatment. However, complicated operation is unnecessary with the new structure, since the interface functional part is integrated with the main unit. Overall performance of dentists does not depend on experience, ability, and technique. The new structure is expected to meet market needs. There is possibility that fundamental performance of strength and durability to be degraded by unifying the main unit and the interface function part, though. It is considered to be a kind of destructive innovation in this respect. It is expected that its performance improves with progress of sustaining technology.

V. CONCLUSION

Hard resin for crowns was developed in order to cope with the change of outside environment. The company was able to market the product by cooperation with a university, the transfer of tacit knowledge, and employment of the talented people who understood the application technology despite of scarce management resources. Although it was a catch-up of the other company, the product came up with better performance than the competitors. It created new needs in the market and became popular. A new integrated structure is proposed having main unit and interface function in dental composite resin. Fundamental performance may decrease by the integration. The new structure will bring about a new standard of value, and has the aspect of destructive technology. From a user's viewpoint, it is an innovation that simplifies the sophisticated dental work. The other companies enjoy large profits by the

product line with this interface function, and it is difficult to switch to new structure. A small to medium sized technology oriented manufacturing firm can enter with new standard of value, and it will get competitive advantage. The result of this dental composite resin case will be applicable to various products.

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