

# Design of Intelligent Graphene Facial Physiotherapy Instrument Based on Concept of Comprehensive Health

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**Abstract.** In order to develop an intelligent facial physiotherapy instrument for facial paralysis relying on traditional Chinese medicine physiotherapy, the product is designed through a complete design process centered on the user. Use observation method, questionnaire method, interview method, card classification method to conduct research, and analyze the design principles through expert interview method and AHP. Combining the ergonomic data of the human face, comprehensively considering the material properties and production and processing technology, a model of the facial physiotherapy instrument is designed. And debug according to the prototype of the product to establish an intelligent service system for the product. Designed an intelligent facial physiotherapy instrument supported by the three technologies of graphene releasing far-infrared waves, electric pulse output micro-current, and variable frequency mechanical vibration, and made up for the lack of functions of existing products on the market by integrating new technologies and innovative applications. Provide new ideas for facial paralysis rehabilitation and facial physiotherapy.

**Keywords:** facial physiotherapy instrument, graphene, technology integration, product development, service system

## 1. Introduction

With the aging of the population and the increasingly serious sub-health problems, the concept of comprehensive health, which embodies the whole process of life, all-round and continuous care, has been valued by more people. Rehabilitation physiotherapy products are increasingly becoming indispensable for people to perform post-diagnosis assisted rehabilitation and daily recuperation [1]. Contemporary people's lives are fast, their work and rest are irregular, and the sub-healthy lifestyle increases the risk of facial diseases. The prevalence of facial paralysis is increasing and the affected population is showing a younger trend. In the normalized prevention and control of COVID-19, protective equipment induced skin problems, which brought the need for facial problem prevention and skin care. [2].

Facial physiotherapy instruments are widely used due to their advantages of convenience, multi-function and remarkable effect. Based on the concept of comprehensive health, this research integrates and uses new technology, integrates traditional Chinese medicine acupoint massage and new technology into physiotherapy products, and develops and designs the facial physiotherapy instrument to protect the user's facial health.

## 2. Current Status of Facial Nerve Palsy

Facial nerve palsy is an acute disease. Many people also call it facial palsy. The main clinical manifestation of facial nerve palsy is that the facial muscles on the affected side of the patient's face are paralyzed. With the irregular life and rest of the contemporary people, the increase in life pressure, and the increase in work pressure, increase the risk of causing facial paralysis. Sudden stimulation of cold and cool breeze in life, or due to excessive fatigue, long-term mental work, or greater psychological stimulation may cause facial paralysis [3].

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At present, the clinical treatment of facial nerve palsy by western medicine mainly relies on drug treatment. The clinical efficacy of these drugs is acceptable, and the therapeutic effect is good, but the side effects of these drugs are very large, which can cause a variety of adverse reactions in patients. The theory of traditional Chinese medicine believes that in patients with facial paralysis, the body's righteousness is relatively weak, which leads to the emptiness of the veins and the decline of the body's resistance and defense functions. And related tissues such as facial tendons and muscles lack blood nutrition for a long time, causing tendons to relax and lose their use. Compared with Western medicine treatment, acupuncture treatment of peripheral facial paralysis has the characteristics of good therapeutic effect, simple operation, and small adverse reactions. Therefore, it is increasingly used as the first choice for treatment by more and more patients. The auxiliary rehabilitation function of facial physiotherapy equipment can not only reduce the burden of patients who often go to the hospital for rehabilitation treatment, prevent recurrence in the later stage of rehabilitation, but also provide patients with more convenient and longer-lasting auxiliary treatment protection. Relieve treatment anxiety of patients. It can also prevent paralysis after rehabilitation or other facial diseases.

### 3. Process Construction of Product System Design of the Facial Physiotherapy Instrument

User experience is an important criterion for judging products. In the entire design cycle of the facial physiotherapy instrument, we adhere to the user-centered design concept and integrate user needs throughout the design. The process of product system design and construction of the facial physiotherapy instrument is shown in Figure 1. Combined with user research and market research, the design strategy of the instrument was formulated according to user needs, laying a foundation for subsequent design practice [4].

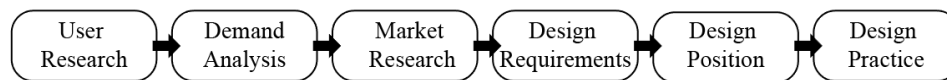


Fig. 1: Design process of graphene intelligent facial physiotherapy instrument.

## 4. Design Research of the Facial Physiotherapy Instrument

### 4.1. User Group Characteristics Analysis

The age of facial paralysis patients is distributed in various age groups, but there are obvious age differences. The prevalence of people aged 30-69 has stabilized, while the prevalence of people aged 10-29 has shown an upward trend in recent years. In other words, facial paralysis patients are getting younger and younger, and young people are beginning to face the threat of facial paralysis [5]. This questionnaire survey adopts the questionnaire survey method, randomly selects the public, and makes the questionnaire of "Facial Physiotherapy Apparatus Related Survey". A total of 200 questionnaires were distributed, and 198 valid questionnaires were returned. The results of the questionnaire found that 67% of people have facial health problems and 88% are worried about facial problems. 71% of people are willing to use facial physiotherapy instruments to prevent and treat facial diseases. Among them, the proportion of young people is higher than that of middle-aged people, and the proportion of women is higher than that of men. Among the 63 patients with facial paralysis in the questionnaire, 28 were women and 35 were men, aged 20 to 60 years old. Among them, 41 cases of facial paralysis were cured by TCM physical therapy, and 22 cases were in the treatment stage of facial paralysis. All 63 patients with facial paralysis are positive about having facial physiotherapy equipment that can replicate rehabilitation. Ninety-five percent of the people expressed trust and support for the treatment of facial paralysis by Chinese medicine, and 92% expressed the hope that facial physiotherapy instruments could assist in the treatment of facial paralysis during the rehabilitation stage. The main reason for the positive attitude towards facial physiotherapy equipment is that patients believe that the auxiliary treatment and rehabilitation methods of TCM physiotherapy are more conservative and safer. 95% of patients with facial paralysis are willing to use facial physiotherapy equipment to prevent the recurrence of facial diseases such as facial paralysis.

The young and middle-aged groups with an increasing incidence of facial paralysis not only play a very important social role, but also shoulder major social responsibilities. Increase the risk of facial problems and

facial paralysis in young and middle-aged people. However, for the treatment of facial paralysis with a long treatment cycle and long recovery time, they need to go to the hospital for a long time and frequently in their busy work and life. Therefore, the demand for auxiliary rehabilitation treatment products for facial paralysis is even stronger. As the metabolism slows down, the ability to recover after illness decreases, and facial paralysis is at risk of aggravation and sequelae. Therefore, there is a strong demand for the long-term daily health care function of facial physiotherapy.

#### 4.2. Explore User Needs and Find Opportunities for Design Innovation

We selected 16 of the 63 patients with facial paralysis as typical users to conduct in-depth interviews with them. The user's needs were sorted and sorted through the card sorting method. Finally, the user's needs for the facial physiotherapy instrument were summarized into three categories: functional needs, experience needs, and aesthetic needs (Figure 2).

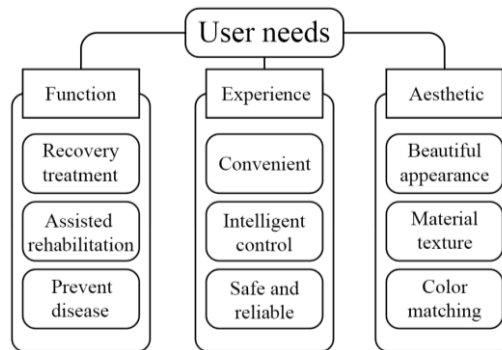


Fig. 2: User needs classification of the facial physiotherapy instrument.

#### 4.3. Comparison and Analysis of Market-Related Facial Products

At present, facial physiotherapy instruments on the market can be roughly divided into two categories. One category is physiotherapy devices with medical effects. They use low-frequency pulse currents to stimulate acupoints and nerves, and use mechanical massage to treat facial diseases such as facial paralysis. Such products have single functions and insufficient universality, resulting in low overall product utilization and lack of innovation in form and function. There is still room for improvement in technological innovation and the use of new materials. The other is the physiotherapy instrument with cosmetic effects, which uses technologies to promote the absorption of skin care products or promote skin tightening. There are few effective prevention and treatment products for facial paralysis in the market. Existing facial physiotherapy products generally have common problems such as single function, product homogeneity trend, and low added value. And it is difficult to meet the needs of users in terms of function, experience and aesthetics.

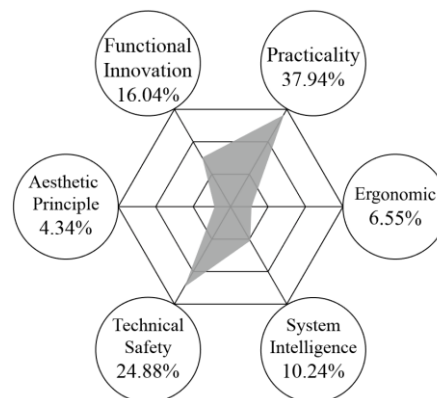


Fig. 3: The proportion of the importance weight of the design requirements.

### 5. Design Positioning of the Facial Physiotherapy Instrument

#### 5.1. Mapping from User Needs to Product Design Strategy

Through the above survey and analysis of user needs, it can be seen that the user's functional requirements for the facial physiotherapy instrument can be divided into two aspects: medical treatment and

physiotherapy. Therefore, the function of the product must be innovative and practical. The design strategy of the product also includes: the product technology must be safe and reliable, ergonomic, and improve the comfort of the use process. At the same time, the intelligent system of the product will bring convenience and speed to use. And the product should meet the user's aesthetic standards[6]. Through the analysis of user needs, the user needs are summarized and transformed into six types of design strategies. Since the product is a medical type, the opinions of medical experts have an important guiding role in the research and development and design of the product. Therefore, 12 experts are interviewed, and the experts are allowed to carry out the design strategy of the product through the analytic hierarchy process. The importance is sorted to guide the design of the product as shown in Figure 3.

## **5.2. Integrate New Technologies to Realize Product Functions**

In medical treatment, acupuncture and moxibustion, a traditional Chinese medicine treatment method, has a significant therapeutic effect on patients' pain. It has been praised by more people and has been more widely used [7]. These types of acupuncture products are mainly divided into two categories. One is the electronic acupuncture physiotherapy device that uses similar acupuncture output equipment, through which acupuncture can be conveniently performed. The advantage of this type of product is that the internally heated silver needle can achieve internal heating. It reaches deep into the patient's area. The inconvenience of patients during use will affect the acupuncture experience and the effect of acupuncture. The other is pulse electronic acupuncture. The physiotherapy instrument mainly relies on the form of electronic pulses, simulating traditional Chinese medicine acupuncture and moxibustion techniques to massage the body. Electrical impulses can train muscles innervated by nerves and transmit impulses to the central nervous system, thereby improving the functional state of the nervous system. At the same time, it can increase the permeability of the cell membrane. The adjuvant treatment of electric pulse can effectively improve the comprehensive recovery of the patient during the recovery period. The effect of treatment. In 2004, Lianfang Chen and others from the Shanghai Acupuncture and Meridian Institute explored non-acupuncture treatments for peripheral facial nerve palsy, which fully affirmed the clinical effect of the electric pulse. Electric pulse is an effective method to simulate acupuncture. It has been widely used in clinical treatment and rehabilitation of facial paralysis. It uses pulse waves below 1000HZ to penetrate facial acupuncture points, nerve muscles and cells. And accelerates the recovery of facial nerve conduction function. [8]. Therefore, this design selects convenient and safe electric pulse physiotherapy technology to realize the function of acupuncture and moxibustion physiotherapy for patients with facial paralysis.

It is mentioned in Hunan Journal of Traditional Chinese Medicine that facial acupoint massage is the best way to prevent and relieve facial paralysis [9]. During treatment, facial massage can be performed by massaging the acupoints of the face such as Yifeng, Sibai and Fengchi to relieve the symptoms of facial paralysis. Xiaoli Gan, Department of Huanggang Central Hospital, and others observed the effect of acupoint massage on refractory facial paralysis. It was finally confirmed that acupoint massage has a significant effect in the treatment of refractory facial paralysis [10]. The mechanical vibration generated by the motor imitates the kneading action in traditional Chinese medicine massage. The muscles and acupoints of the user are massaged through the movement of the mechanical structure, so that the muscles can reach a relaxed state, which can effectively assist the patient and relieve exercise fatigue. The bionic kneading method promotes the proper movement of subcutaneous elastic fibers, increases facial blood circulation, can quickly relax facial muscles, relieve facial swelling and improve capillary stasis.

The Baoji Hospital of Traditional Chinese Medicine confirmed that acupuncture plus far-infrared therapy can significantly shorten the course of the disease, increase the cure rate and reduce the risk of sequelae through a controlled trial of 80 patients with facial paralysis [11]. Graphene can radiate far-infrared rays during the heating process, and at the same time, it can radiate far-infrared light waves similar to human body radiation [12]. These far-infrared waves "resonate" with the water molecules on the human face. The activity makes it in a higher vibration state, promotes facial blood circulation, and strengthens the effect of acupuncture on facial paralysis. At the same time, graphene can improve the growth ability of animal cells by promoting the adhesion and proliferation of animal cells, and can effectively accelerate the continuous differentiation, division, proliferation and transformation of stem cells into neuron-like cells and promote cell

growth. Graphene used in facial physiotherapy products can strengthen the metabolism between various tissues of the face, enhance cell regeneration, and increase the recovery speed of facial paralysis.

Combining the traditional Chinese medicine physiotherapy methods and technologies for the treatment of facial paralysis, taking into account the needs of users and product design strategies, the final choice of electric pulse, frequency conversion mechanical vibration and graphene heating technology with significant therapeutic effect, safety and no side effects. The three technologies are combined and applied to the design of the instrument as technical support to provide users with facial paralysis treatment and auxiliary rehabilitation functions.

## 6. Implement the Design Plan through Design Practice

Considering the arrangement of facial acupuncture points and combining the design positioning of bionic design, the key measurement range of human face and head data is determined. Through the measurement of human face ergonomics data and the collection of convention popular values, combined with database data, the practical data in the ergonomic sense required by the key parts in the design of the facial physiotherapy instrument are determined. And the design scheme is iteratively improved according to user needs and design strategies. The final iterative improvement of the agile development design is shown in Figure 4.

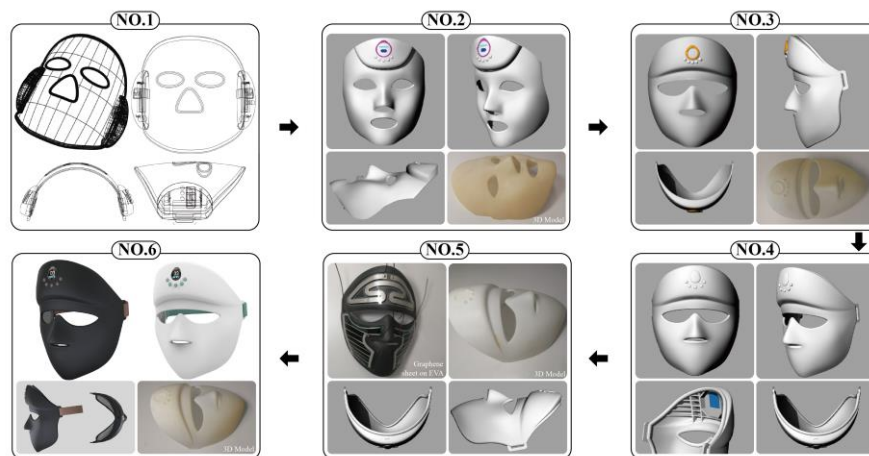


Fig. 4: Design scheme iteration of graphene intelligent facial physiotherapy instrument.

First of all, the first version of facial physiotherapy instrument chooses the one-dimensional curved shape of the surface material. The product brings a good impression to the user through comfortable visual and tactile experience, brings a comfortable experience during use, and finally brings a continuous good experience to the user. So we choose the silicone material, among which the silicone is 50 degrees of hardness. Through the proofing experience, it is found that the 50 degrees of hardness silica gel can bring users a comfortable wearing experience. Silicone has a certain degree of flexibility, good flexibility and heat resistance. At the same time, it has flexible adaptability and can meet the range of different faces.

The control circuit board, rechargeable battery, control buttons and other originals are placed on both sides close to the ears, and silicone protective strips are added at the edges to create a relatively closed space to ensure the physiotherapy effect. Such a design can meet the requirements of safety and reliability of the technology while reasonably arranging components. However, through testing, it is found that such a simple curved shape cannot fit the face to the maximum, and it is difficult to ensure that the product can fully contact the face in the massage and kneading mode, which affects the comfort and practicability of the product.

In the second version, the product shape is designed into an organic form according to the undulating trend of the facial curve, and the electrical part is moved to the top. Only one electrical cavity is needed this time, so the product shape is more complete, and the integrity is significantly improved. The structure of the physiotherapy instrument in the organic form can fit the face more effectively, and can more effectively and accurately locate the functional points corresponding to the acupoints on the physiotherapy instrument. This improvement effectively improves the product, it makes the product more ergonomically designed, and

further improves the comfort of the product when it fits the user's face, but the processing technology is more complicated, and the mold production is required to increase the production cost of the product.

The use scene was simulated through the prototype, and 30 young and middle-aged people were recruited to introduce the product functions and through observation of the simulation scene and user feedback, it was found that there was no need to reserve the position of the mouth during the use of the product, so the window design of the mouth was cancelled. Such improvement not only further improves the practicability of the product, but also improves the overall aesthetics, and meets the user's needs for practicality in function and comfort and beauty in use experience. In the fourth version of the scheme, the modelling fluency was adjusted in detail through the prototype test, and the matching components required by the product were determined, and then the space required to construct the facial physiotherapy instrument apparatus was determined according to the interference conditions of space structure.

At the same time, the structure of the fixing elements inside the facial physiotherapy instrument is designed. Because the instrument is made of silicone material, it is not suitable for rigid fixing methods such as screws. Using the deformable physical properties of silicone, the interference fit is selected to fix the circuit board through the silicone wrap. Considering the interference conditions of the structural space, the basic type of the printed circuit board is an octagon, the octagon is not easy to rotate, and the fixing method with the silicone interference fit is also very stable and firm. Since the face is very important and fragile to the user, the stable structure and no metal exposure can reduce the user's worry and bring the user a safe and reliable feeling. And combined with the product setting function, the design of the single-chip microcomputer and the proofing of the components are completed (as shown in Figure 5).

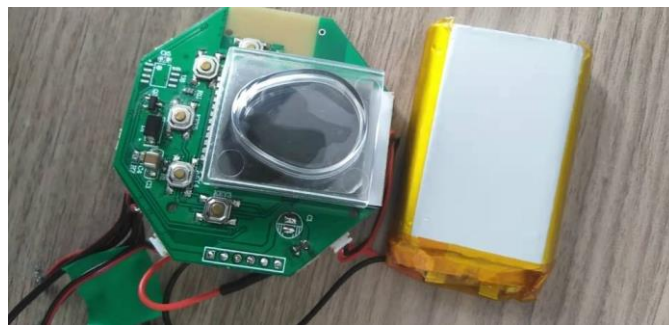


Fig. 5: Display plastic cover and printed circuit board.

The fifth edition further considers the processing details of the material. Combined with the silicone processing process, the shape of the product under the forehead was adjusted, which is more conducive to the mass production and processing of the physiotherapy instrument. The inside of the rubber shell is made of EVA material with good air permeability. This material is smooth on the outside and the plush touch on the inside can bring a soft and warm touch to the patient's face, which can bring a safe and comfortable experience to the user. EVA material does not interfere with infrared light waves, and its soft physical characteristics make it well adapted to the deformation caused by mechanical vibration massage, and will not interfere with the heating of the product and the massage technology. The product shell was repeatedly tested and adjusted through 3D printing.

Sibai, Jumiao and Zygomatica are important acupoints for the treatment of facial paralysis. Stimulating the temples can bring benign stimulation to the brain, thereby alleviating headaches and fatigue [13]. According to the importance of acupuncture points and the balance of their distribution, comprehensive expert opinions and vibration motor assembly issues, the selection of acupuncture points for the facial physiotherapy instrument includes: Sibai, Dicang, Taiyang, Tinggong, Cheek, Xiaguan, etc. The significance lies in: taking into account the health of the face, assisting the rehabilitation of facial paralysis, and maintaining the facial nerves. As shown in Figure 6, A, B, and C are respectively the three selected positions of variable frequency vibration. Among them, the massage acupoints of the three vibration placement points include important acupoints for the treatment of facial paralysis: Sibai, Dicang, Zygomatic, Jumiao and Xiaguan points. A, b, and c are three pulse stimulation positions respectively, and the stimulation points include temple, Tinggong and Jiache. There are 6 placement points symmetrically placed on the left and right sides of the physiotherapy instrument. A total of 12 key physiotherapy positions are used to imitate

traditional Chinese acupuncture and massage to perform physiotherapy on related acupoints. Because graphene heating technology has good physiotherapy effects, the graphene heating sheet should cover multiple facial acupoints as much as possible when designing the heating area, which can effectively improve the curative effect of the auxiliary treatment of facial paralysis and meet the user's demand for product effectiveness.

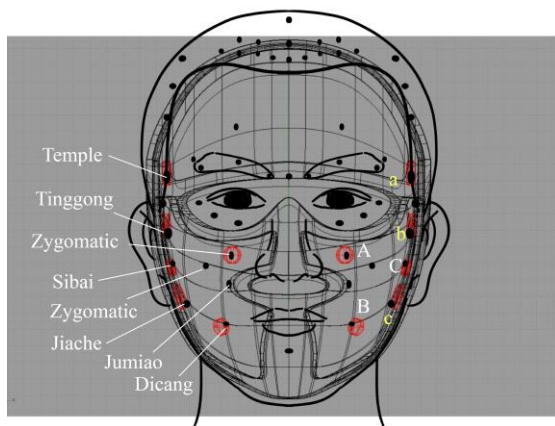


Fig. 6: Electric pulse and vibration massage acupuncture point location.

Finally, the details of the product were improved, and a suitable strap and a fixed position for the strap were added to the main body. A model of the final design was printed and assembled with the internal components. The design of facial physiotherapy equipment and the production of prototypes are completed.

## 7. Service System Construction

As an important instrument for the auxiliary treatment of facial paralysis, the facial physiotherapy instrument is connected to the smart medical service system to establish information exchange between patients and doctors through the Internet of Things in the home medical scene, which not only facilitates the diagnosis, tracking and medical record management of patients by doctors, but also to a great extent, patients with instant facial paralysis need frequent physical therapy, and it also provides convenience for convenient physical therapy for families in the post-epidemic era. In order to provide a better user experience and a full range of continuous care for the user's facial health, a product service system for facial physiotherapy instrument has been established (Figure 7).

The intelligent product system supports the operation of the user's mobile terminal (Figure 8). The user can select the duration and mode of physiotherapy through the application mini-program according to personal needs or doctor's suggestion, and provides users with physiotherapy records and online consultation functions, which can be personalized and professional. The service system provides convenient, fast and professional facial physiotherapy experience for patients with facial paralysis [14]. The establishment of the service system can meet the needs of users for product functions and user experience.

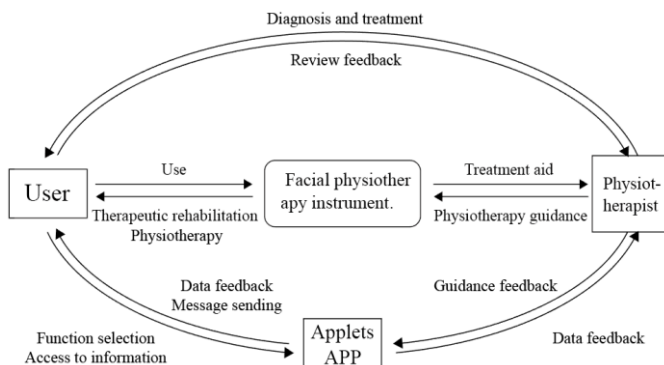


Fig. 7: Product service system of the facial physiotherapy instrument.

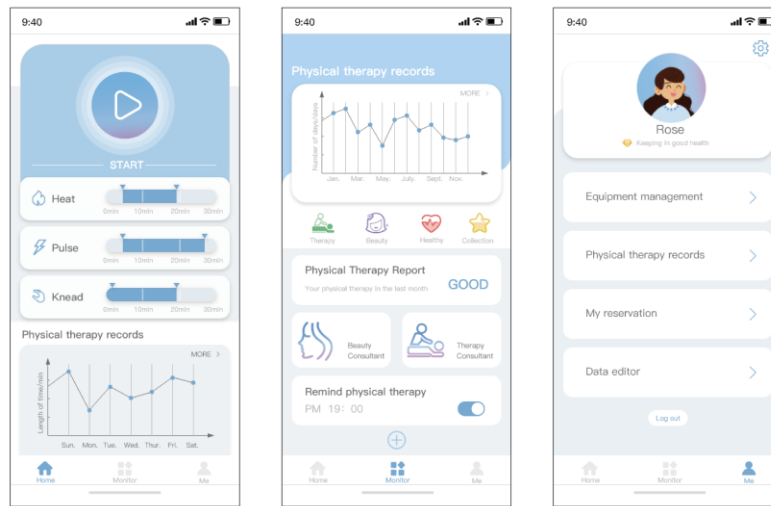


Fig. 8: Product service system of facial physiotherapy instrument.

## 8. Conclusions and Prospect

Through a complete design process, the facial physiotherapy instrument combined with user research for facial nerve patients can provide rehabilitation and auxiliary treatment for patients with nerve anesthesia, facial paralysis, skin and other treatment problems. The product can be used as a daily beauty and skin care instrument, and can provide long-term daily care or auxiliary treatment for the user's care and health through a combination of prevention and treatment.

With new physiotherapy concepts and design concepts, TCM acupoints and new TCM physiotherapy and massage will be given new connotations to physiotherapy. The application of new materials will continue to broaden the path of TCM physical therapy. In addition, with the trend of modern development of TCM physiotherapy and comprehensive health era, the development of physiotherapy medical products with graphene as the main technology has a good application development. Our research on the graphene intelligent physiotherapy instrument will continue. The status quo of development provides new ideas and reference value for the research of nursing physiotherapy, auxiliary treatment and related products under the skin nerve physiotherapy technology.

## 9. Acknowledgment

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