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Design and Development of an Automatic Temperature Controlled Eye Mould for Netra Tarpana Therapy: A Review

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Abstract-Netra Tarpana is a traditional Ayurvedic ocular therapy in which medicated Ghrita is retained around the eye for a prescribed period. Conventional Netra Tarpana generally uses a manually prepared dough boundary and requires manual monitoring of the therapeutic medium, particularly its temperature. This may lead to variations in temperature, treatment conditions, and overall consistency. The integration of modern engineering techniques can help overcome these limitations while retaining the basic principles of the traditional procedure. This review paper presents the design and development concept of an automatic temperature-controlled eye mould for Netra Tarpana therapy. The proposed system combines a flexible eye mould, heating element, temperature sensor, microcontroller, and feedback-based control mechanism to continuously monitor and regulate temperature. PWM-based heating control, thermal insulation, temperature display, treatment timer, and safety cut-off mechanisms are considered to improve temperature stability and operational safety. The review discusses existing research related to Netra Tarpana, mould heating, thermal insulation, biomedical temperature control, sensor integration, silicone materials, and compact heating systems. The proposed approach aims to improve the standardization, repeatability, convenience, and temperature management of Netra Tarpana by integrating traditional Ayurvedic practice with modern mechanical, thermal, and electronic technologies.

Keywords-Netra Tarpana, Ayurvedic Therapy, Eye Mould, Automatic Temperature Control, Temperature Sensor, Microcontroller, Heating Element, Thermal Insulation, Biomedical Device.

I. Introduction

Netra Tarpana is a traditional Ayurvedic ocular therapy in which medicated Ghrita or other suitable therapeutic substances are retained around the eye for a prescribed period. Traditionally, the procedure is performed by preparing a dough-based boundary around the eye and filling it with the therapeutic medium. It is described in Ayurvedic literature as a procedure intended to nourish, rejuvenate, and support normal eye function, and has been discussed in relation to conditions such as dryness, fatigue, irritation, and other ocular complaints. However, conventional Netra Tarpana depends largely on manual preparation and supervision, which can lead to variations in the size, shape, sealing, and overall consistency of the treatment arrangement. Maintaining an appropriate and stable temperature of the therapeutic medium is an important consideration during the procedure. In conventional practice, temperature is generally monitored and maintained manually, which may result in temperature fluctuations and the need for repeated reheating. Recent developments in biomedical engineering provide opportunities to overcome these limitations through the use of temperature sensors, microcontrollers, heating elements, and feedback-control systems. Resistive heating elements combined with PWM-based control can regulate the heat supplied to the system, while continuous temperature feedback can help maintain a desired set point and reduce the possibility of excessive heating. These technologies can therefore be incorporated into a reusable eye mould for improved temperature management and repeatability. The proposed work, "Design and Development of Automatic Temperature-Controlled Eye Mould for Netra Tarpana Therapy," aims to integrate the traditional concept of Netra Tarpana with modern mechanical, thermal, and electronic technologies. The proposed mould incorporates a suitable flexible material, controlled heating element, temperature sensor, microcontroller, and feedback-based temperature-control system, along with features such as a digital temperature display, treatment timer, and safety cut-off.

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The proposed work, "Design and Development of Automatic Temperature-Controlled Eye Mould for Netra Tarpana Therapy," aims to integrate the traditional concept of Netra Tarpana with modern mechanical, thermal, and electronic technologies. The proposed mould incorporates a suitable flexible material, controlled heating element, temperature sensor, microcontroller, and feedback-based temperature-control system, along with features such as a digital temperature display, treatment timer, and safety cut-off. The prototype will be evaluated through laboratory testing of heating time, temperature stability, temperature uniformity, energy consumption, and safety response. The overall aim is to develop a standardized and reusable system that provides controlled thermal conditions while retaining the fundamental procedure of Netra Tarpana therapy.

II. Literature Review

Netra Tarpana is a traditional Ayurvedic eye therapy in which medicated Ghrita is retained around the eye for a specific period. Previous studies have explained the procedure, therapeutic importance, indications, contraindications, and its use in maintaining overall eye health. The literature also discusses the nourishing and rejuvenating effects of Tarpana and its application in conditions such as dry eye. However, the conventional procedure mainly uses a manually prepared dough structure and requires manual handling of the therapeutic medium. This indicates a need for a standardized, reusable, and more convenient eye mould for the therapy [1]–[4]. Previous studies on thermal management provide useful information for designing the proposed eye mould. Research on mould-heating systems shows that the heating element must be properly positioned to achieve uniform temperature distribution and avoid the formation of hot spots. Studies on thermal insulation also show that suitable insulation can reduce heat loss and improve heating efficiency. These concepts can be applied to the proposed eye mould by carefully selecting the heater arrangement, insulation material, and heat-transfer path [5], [6].

Automatic temperature control is another important consideration in the proposed system. Earlier research on biomedical temperature-control systems has demonstrated the use of temperature sensors and feedback mechanisms to continuously monitor and regulate heating. PWM control can be used to adjust the power supplied to the heating element by changing its duty cycle, which helps in achieving more stable temperature control. The integration of a temperature sensor with a microcontroller can further allow the system to automatically adjust the heater according to the measured temperature [7], [9], [10].

The combination of traditional therapies with modern engineering methods can improve the consistency, monitoring, and repeatability of treatment procedures. Biomedical-device design approaches can be used to develop a reusable and controlled system for Netra Tarpana. Silicone is considered suitable for the mould because of its flexibility, ease of moulding, moisture resistance, and thermal properties. In addition, proper thermal-system design is required to determine the suitable position of the heater, insulation layer, temperature sensor, and control system so that the device operates efficiently [8], [11]–[13]. Research on compact heating systems for wearable biomedical devices also provides useful design considerations for the proposed eye mould. Such systems need to be lightweight, compact, energy-efficient, and capable of providing controlled heat. These requirements are particularly important for an eye mould because it must be comfortable for the user while maintaining uniform temperature around the therapeutic area. Based on the available literature, the proposed system combines a flexible eye mould, temperature sensor, heating element, microcontroller-based PWM control, thermal insulation, and safety features to provide automatic and stable temperature control during Netra Tarpana therapy [14].

III. Traditional Techniques Used in Netra Tarpana Therapy

1. Preparation of Patient and Dough Boundary: Netra Tarpana is a traditional Ayurvedic ocular therapy performed under Netra Kriyakalpa. In the conventional method, the patient is positioned comfortably and the area around the eye is cleaned before treatment. A soft dough is prepared and shaped into a circular or oval ring around the eye. The dough boundary is carefully pressed against the surrounding skin to form a temporary reservoir for retaining the medicated Ghrita. The size and shape of the dough ring are adjusted manually according to the patient's eye region to minimize leakage.

2. Preparation and Application of Medicated Ghrita: The prescribed medicated Ghrita is prepared according to the relevant Ayurvedic procedure and brought to a suitable warm condition before application. It is then slowly poured into the dough enclosure until the eye is adequately covered. The Ghrita is retained around the eye for a prescribed duration while the patient remains relaxed. During the procedure, the practitioner observes the patient and manually manages the therapeutic medium when required. Maintaining a suitable temperature is an important practical consideration because the Ghrita gradually loses heat to the surrounding environment.

3. Temperature and Treatment Management: In the traditional method, the temperature of the therapeutic medium is generally assessed and managed manually by the practitioner. As the treatment progresses, the temperature can change due to heat loss and environmental conditions, which may require manual intervention. Treatment duration is also monitored according to the applicable therapeutic protocol. The dependence on manual temperature monitoring, reheating, dough preparation, and timing can result in variations between treatment sessions and makes precise temperature control difficult.

4. Removal and Post-Treatment Procedure: After completion of the prescribed treatment duration, the medicated Ghrita is carefully removed from the dough enclosure. The dough ring is then gently removed from around the eye, and the surrounding area is cleaned. Appropriate post-treatment instructions are provided by the practitioner. Although the traditional technique is simple and widely described in Ayurvedic literature, the disposable dough boundary, manual sealing, variable dimensions, and manual temperature management present opportunities for engineering improvement.

5. Need for an Improved Technique: The proposed automatic temperature-controlled eye mould aims to overcome these practical limitations while retaining the fundamental principle of Netra Tarpana. A reusable flexible mould can replace the manually prepared dough boundary, while a temperature sensor can continuously monitor the therapeutic medium. A microcontroller-based PWM or PID control system can regulate a low-voltage heating element according to a clinician-defined temperature set point. Thermal insulation, a digital temperature display, an automatic timer, and an independent safety cut-off can further improve temperature stability, repeatability, and operational safety. Thus, the proposed system integrates traditional Ayurvedic therapy with modern mechanical, thermal, and electronic engineering techniques

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IV. Value Creation Opportunities

The proposed automatic temperature-controlled eye mould for Netra Tarpana therapy creates value by addressing practical limitations of the traditional method and combining Ayurvedic principles with modern mechanical, thermal, and electronic technologies. The major value-creation opportunities are discussed below.

1. Automatic Temperature Regulation: One of the major opportunities is the automatic regulation of the temperature of the therapeutic medium. In the traditional method, the temperature is generally monitored and maintained manually, which can result in fluctuations during the procedure. The proposed system uses a temperature sensor to continuously measure the temperature and a microcontroller to control the heating element. This can provide more consistent thermal conditions and reduce the need for repeated manual heating.

2. Standardized Eye Mould: Traditional dough-based boundaries can differ in shape, size, thickness, and sealing depending on how they are prepared. The proposed mould can be designed using CAD and manufactured with controlled dimensions. This provides a standardized reservoir around the eye and improves repeatability between different treatment sessions. The mould can also be designed according to different eye sizes to improve adaptability and comfort.

3. Reduction in Manual Intervention: In the conventional procedure, the practitioner may need to prepare the dough boundary, check for leakage, monitor temperature, manage reheating, and monitor treatment duration. Automation can reduce these repetitive activities. The proposed system can automatically regulate temperature and treatment time while allowing the practitioner to supervise the procedure.

4. Enhanced Safety: Safety is an important value-creation opportunity because the system operates close to the eye. The proposed design can include an independent temperature cutoff, sensor-failure detection, emergency stop, timer-based heater shutdown, and controlled low-voltage heating. If an abnormal temperature or sensor fault is detected, the heater can automatically be switched off. These features can provide additional protection compared with uncontrolled heating.

5. Improved Thermal Uniformity: Uneven heating can result in hot and cold regions within the therapeutic medium. The proposed design can use an appropriately distributed heating element and thermal insulation to improve heat distribution. Thermal analysis and experimental temperature mapping can be used to identify hot spots and optimize the heater position. Better thermal uniformity can contribute to more consistent operating conditions.

6. Energy Efficiency: The system does not need to operate the heating element continuously at full power. PWM or PID-based control can adjust the heater power according to the difference between the measured temperature and the desired set point. Thermal insulation can further reduce heat loss. As a result, the system has the potential to reduce unnecessary energy consumption while maintaining the required temperature.

7. Real-Time Temperature Display: An LCD or OLED display can provide real-time information about the operating condition of the device. The display can show the actual temperature, target temperature, heating status, and treatment time. This provides the practitioner with clear information and makes the operation easier to monitor.

8. Automatic Treatment Timer: Treatment duration can be incorporated into the control system using a digital timer. Once the prescribed operating time is completed, the system can automatically stop the heating process and indicate completion. This reduces dependence on manual timekeeping and provides better control of the experimental procedure.

9. Improved Patient Comfort: The mould can be designed with a smooth and flexible patient-contact surface and an ergonomic shape that conforms to the area around the eye. A controlled heating system can reduce sudden temperature changes. The design should also minimize excessive pressure on the surrounding tissues. Material selection and the final geometry should be evaluated for intended contact and cleaning requirements.

10. Reusability: Unlike a manually prepared dough boundary, a suitably designed mould can potentially be reused after appropriate cleaning and reprocessing. This can reduce preparation time and material consumption. Reusability also allows the same mould geometry to be used repeatedly during laboratory testing, making experimental comparisons more reliable.

11. Easy Operation: The proposed system can be designed with a simple user interface containing buttons for setting the temperature and treatment time. A start/stop function and clear display can make the system easy to operate. The goal is to make the device sufficiently simple that the practitioner does not need extensive technical knowledge to operate the basic functions

V. Comparative Analysis

The reviewed literature [1]–[14] covers three major areas relevant to the proposed automatic temperature-controlled eye mould for Netra Tarpana therapy: the traditional and therapeutic aspects of Netra Tarpana [1]–[4], thermal management and insulation [5], [6], and modern biomedical temperature-control and device-integration techniques [7]–[14]. The Ayurvedic studies mainly focus on the procedure, therapeutic importance, and clinical application of Netra Tarpana, whereas the engineering studies focus on temperature regulation, heating uniformity, sensor integration, materials, and compact device design. However, the reviewed studies address these aspects separately, creating an opportunity to integrate them into a single automated system. The first group of studies [1]–[4] establishes the traditional and therapeutic foundation of Netra Tarpana. These studies describe the use of medicated Ghrita, the method of retaining the therapeutic medium around the eye, and its application in ocular health. However, the emphasis is mainly on the Ayurvedic procedure rather than on engineering control. The conventional method requires manual preparation of the dough boundary, manual temperature management, and supervision throughout the procedure. Therefore, these studies provide the therapeutic background but leave scope for improving the standardization and automation of the treatment setup.

The studies related to thermal management [5] and [6] provide important engineering principles for the proposed mould. The heating-system research [5] emphasizes uniform temperature distribution, which is important because improper heater placement can create localized hot spots. The thermal-insulation study [6] highlights the importance of reducing unwanted heat transfer and improving thermal efficiency. Compared with the traditional method, these engineering approaches provide a basis for designing the proposed mould with a properly positioned heating element and insulation layer to achieve more controlled and efficient heating. The biomedical control studies [7], [9], and [10] provide the basis for the automatic temperature-control system. Temperature sensing [7], sensor integration [10], and PWM-based heater control [9] can be combined to create a closed-loop system. In the proposed design, the temperature sensor continuously measures the therapeutic-medium temperature, the microcontroller compares it with the desired set point, and PWM control adjusts the power supplied to the heating element. This is an improvement over manual temperature monitoring because the heating process can respond automatically to temperature changes.

The device-design and material-related studies [8], [11]–[14] provide additional concepts for developing the physical system. Integration of traditional therapies with modern biomedical engineering [8], suitable flexible silicone material [11], thermal-system optimization [12], engineering applications in Ayurveda [13], and compact heating systems [14] collectively support the development of a small, flexible, efficient, and standardized eye mould. Compared with the traditional dough-based arrangement, the proposed design can provide consistent geometry, controlled heating, digital monitoring, and improved repeatability.

Table 1. Traditional Netra Tarpana vs. Proposed Automatic Temperature-Controlled Eye Mould

Parameter	Traditional Netra Tarpana	Proposed Automatic Eye Mould
Mould/Boundary	Manually prepared dough ring	Reusable engineered eye mould
Material	Flour/dough-based material	Flexible silicone or equivalent
Temperature Control	Mainly manual	Automatic closed-loop control
Temperature Measurement	Manual thermometer/observation	Integrated temperature sensor
Heating Method	Manual warming/reheating of Ghrita	Controlled electrical heating element
Controller	No electronic controller	Arduino/ESP32 or similar microcontroller
Power Control	Manual	PWM/PID-based control can be used
Temperature Stability	May vary during treatment	Designed for improved stability
Heating Uniformity	Depends on manual heating	Distributed heater arrangement
Temperature Display	Usually manual measurement	Digital display
Treatment Timer	Manually monitored	Automatic timer
Over-temperature Protection	Practitioner-dependent	Automatic safety cut-off
Sensor-failure Protection	Not applicable	Heater can be automatically disabled
Heat Loss	Relatively difficult to control	Reduced using suitable insulation
Repeatability	Depends on practitioner and mould preparation	More standardized
Portability	High	Potentially high with compact design
Maintenance	New dough boundary may be prepared for each procedure	Reusable mould, subject to validated cleaning and clinical requirements
Engineering Complexity	Low	Moderate
Temperature Safety	Primarily dependent on manual monitoring	Multiple electronic/thermal safety mechanisms can be incorporated

Challenges

The development of an automatic temperature-controlled eye mould for Netra Tarpana therapy involves several thermal and mechanical challenges. One of the major difficulties is maintaining a stable and appropriate temperature of the therapeutic medium throughout the procedure, as heat is continuously lost to the surroundings while excessive heating may cause temperature overshoot. Uniform heat distribution is also important because improper heater placement can create localized hot spots and cooler regions. The temperature sensor must therefore be positioned carefully to provide an accurate and responsive measurement. Proper heater arrangement, thermal insulation, sensor placement, and temperature mapping are required to achieve reliable thermal performance. The mechanical design and electronic control system also present significant challenges. The mould must provide an effective seal around the eye to prevent leakage while remaining comfortable and suitable for different eye-region shapes and sizes. The selected material should have appropriate flexibility, durability, thermal stability, and compatibility with the intended cleaning and reuse process. On the electronic side, the temperature sensor, microcontroller, heating element, power circuit, display, timer, and control system must work together reliably. Selection and tuning of ON/OFF, PWM, or PID control must consider heater power, sensor accuracy, thermal response, and temperature stability. Since the device operates close to the eye and therapeutic medium, suitable electrical insulation and low-voltage operation are also important. Safety and clinical validation are the most critical challenges in the proposed system. Software-based control alone may not be sufficient in cases of sensor failure, controller malfunction, or unexpected temperature rise; therefore, independent over-temperature protection, emergency shutdown, sensor-fault detection, and automatic heater disconnection should be incorporated.

The prototype should be evaluated for temperature accuracy, heating time, temperature uniformity, overshoot, energy consumption, electrical safety, leakage, and mechanical durability under laboratory conditions. Furthermore, engineering performance does not establish clinical safety or effectiveness; the appropriate therapeutic temperature, treatment duration, and clinical procedure must be determined and validated by qualified practitioners. Addressing these challenges is essential for developing a reliable and safe system that combines the traditional principles of Netra Tarpana with modern temperature-control technology.

VI. Conclusions

The Design and Development of Automatic Temperature-Controlled Eye Mould for Netra Tarpana Therapy represents an integration of traditional Ayurvedic practice with modern mechanical, thermal, and electronic engineering. Conventional Netra Tarpana generally relies on a manually prepared dough boundary and manual monitoring of the therapeutic medium, which can result in variations in mould geometry, temperature, sealing, and treatment conditions. The proposed approach aims to overcome these practical limitations through a standardized and reusable eye mould with controlled heating and temperature monitoring. The proposed system incorporates a temperature sensor, heating element, microcontroller, PWM/PID-based control, thermal insulation, digital display, timer, and safety cut-off mechanism. Continuous temperature feedback can help regulate the heating element and reduce temperature fluctuations, while appropriate heater placement and insulation can improve thermal uniformity and efficiency. The standardized mould can also reduce preparation time and improve repeatability compared with a manually formed dough boundary.

The literature reviewed in this work demonstrates the relevance of Netra Tarpana therapy, thermal management, sensor-based temperature control, PWM techniques, silicone materials, and biomedical-device design. However, integrating these technologies specifically into an automatic Netra Tarpana eye mould provides an opportunity for further engineering development. The proposed concept can therefore contribute to improved temperature monitoring, standardization, repeatability, convenience, and operational safety. Further work should focus on prototype fabrication, thermal characterization, sensor calibration, control-system optimization, leakage testing, material compatibility, cleaning and reprocessing, electrical safety, and user-comfort evaluation. Most importantly, the actual therapeutic parameters and clinical suitability should be established through appropriate professional and clinical validation. Overall, the proposed system provides a promising engineering pathway for modernizing the delivery and monitoring of Netra Tarpana therapy while retaining its fundamental traditional principles.

Future Scope

The future scope of the automatic temperature-controlled eye mould for Netra Tarpana therapy includes further improvement in temperature accuracy, safety, comfort, and automation. Advanced control techniques such as optimized PID or adaptive control can be investigated to reduce temperature fluctuations and overshoot. Multiple temperature sensors and improved heating elements, such as flexible thin-film heaters, can be explored to achieve more uniform heat distribution. Further development of the mould can include medical-grade flexible materials, improved sealing, customized mould dimensions, and better cleaning and reprocessing characteristics. The system can also be enhanced by integrating wireless communication, data logging, and smartphone-based monitoring.

Temperature, treatment duration, heater operation, and other performance parameters can be recorded for research and system evaluation. Thermal simulation using tools such as ANSYS or COMSOL can help optimize the heater position, mould geometry, and insulation thickness before fabrication. Additional safety features such as redundant temperature sensing, independent hardware cut-off, sensor-failure detection, and emergency shutdown can also be incorporated to improve system reliability. Further work should include detailed laboratory testing of heating time, temperature uniformity, temperature stability, energy consumption, leakage, material performance, and control-system response. After appropriate engineering and safety validation, supervised clinical evaluation can be conducted to assess usability, comfort, and suitability for the intended therapeutic procedure.

In the long term, the system could be developed into a compact, reliable, and standardized device for appropriate Ayurvedic clinical and research environments. The integration of smart sensing, advanced control, customized mould design, wireless monitoring, and thermal optimization can further improve the potential of the proposed system while retaining the fundamental principles of Netra Tarpana therapy

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