



**EFFECTS OF COMBINATION TREATMENT OF LONG-PULSED ND:
YAG 1064NM LASER AND 15% GLYCOLIC ACID FOR
FACIAL REJUVENATION**

SAI LINN LINN

**MASTER OF SCIENCE
IN
DERMATOLOGY**

**SCHOOL OF ANTI-AGING AND REGENERATIVE MEDICINE
MAE FAH LUANG UNIVERSITY**

2025

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**THIS THESIS IS A PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
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THESIS APPROVAL
MAE FAH LUANG UNIVERSITY
FOR
MASTER OF SCIENCE IN DERMATOLOGY

Thesis Title: Effects of Combination Treatment of Long-pulsed Nd: YAG 1064nm Laser
and 15% Glycolic Acid for Facial Rejuvenation

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ACKNOWLEDGEMENTS

First and foremost, I would like to express my profound gratitude to my advisor, Prof. Thamthiwat Nararatwanchai, M.D., Ph.D., for his invaluable guidance, encouragement, and constant support throughout the planning, development, and completion of this research. His mentorship has been a true inspiration throughout my master's journey. I am also deeply thankful to my co-advisors, Kanita Poomarapan, M.D., Ph.D. and Napamon Supornpun, M.D., Ph.D., whose expertise, insightful advice, and thoughtful guidance have been essential in shaping the success of this study.

I would like to extend my sincere appreciation to my chairman, Tanomkit Pawcsuntorn, M.D., for his kind support and constructive input. My heartfelt thanks also go to Assoc. Prof. Wongdyan Pandii, Dr. P.H., for her valuable guidance in statistical analysis, which greatly enhanced the quality of this work.

This study could not have been accomplished without the generous participation of all the volunteers, to whom I am deeply indebted.

I am equally grateful to Mae Fah Luang University for providing financial support and an encouraging academic environment that made this research possible.

On a personal note, I wish to thank my beloved family for their endless love, support, and encouragement, which have been the foundation of my strength. I am also truly grateful to my friends from Myanmar and Thailand, who have continuously supported me both emotionally and physically through challenges and successes alike. Their presence has been a constant source of motivation and inspiration throughout this two-year journey in the Master of Science in Dermatology program at Mae Fah Luang University.

Sai Linn Linn

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Author	Sai Linn Linn
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ABSTRACT

Facial aging is characterized by wrinkles, laxity, and barrier dysfunction, creating demand for minimally invasive rejuvenation therapies. The long-pulsed Nd: YAG 1064nm laser stimulates dermal collagen remodeling, while glycolic acid promotes epidermal exfoliation and cellular renewal. This study evaluated the effects of combining these two modalities for facial rejuvenation.

A prospective interventional study was conducted with 15 participants aged 35–50 years and Fitzpatrick skin types III–V, each receiving 3 treatment sessions at 4-week intervals using long-pulsed Nd: YAG 1064nm laser with 15% glycolic acid. Physician Global Aesthetic Improvement Scale (GAIS) was assessed at weeks 4, 8, and 12, while wrinkle severity, skin viscoelasticity, and trans-epidermal water loss (TEWL) were measured from baseline to follow-up visits. Participant's satisfaction was recorded at week 12, and adverse events were monitored throughout the study.

The combination therapy demonstrated progressive improvements in GAIS scores, significant reductions in wrinkle severity, increased viscoelasticity, and decreased TEWL, indicating enhanced skin structure and barrier function.

All participants reported high to complete satisfaction with treatment outcomes, and no serious adverse effects such as scarring, hyperpigmentation, or prolonged erythema were observed.

These findings suggest that the combined use of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid is a safe, effective, and well-tolerated option for facial rejuvenation. By targeting both dermal and epidermal pathways, this multimodal approach offers synergistic benefits and may serve as a valuable non-ablative therapy.

Keywords: Nd: YAG Laser, Non-ablative Laser, Glycolic Acid, Skin Aging, Facial Rejuvenation



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CHAPTER 1

INTRODUCTION

1.1 Background

Human skin serves as a decorative and vital organ of emotional expression in addition to being a protective barrier ⁽¹⁾. Research has shown that an attractive appearance positively influences social interactions, and maintaining a youthful look is associated with increased self-esteem and stronger social connections ⁽²⁾.

The human face reflects not only one's inner self, nature, and personality, but also the health and aging indications and symptoms. Face wrinkles, a receding hairline, frown lines, nasolabial folds, extra skin on the eyelids, and hollowness under the eyes are indications of aging ⁽²⁾.

Aging is a progressive process marked by the deterioration of physiological function and structural integrity, driven by both intrinsic and extrinsic factors ⁽³⁾. Different layers of skin contribute to various aspects of the aging process. Overall skin sagging and laxity are primarily linked to the loss of reticular dermal collagen. Changes in the superficial dermis are associated with enlarged pores, fine wrinkles, erythema, and telangiectasia, whereas alterations in the epidermis correspond to solar-induced pigmentation changes ⁽⁴⁾.

Long-term UV radiation exposure causes premature skin aging, which manifests as wrinkles, texture loss, and skin laxity ⁽⁵⁾. When exposed to UVB rays, skin fibroblasts create matrix metalloproteinase-1 (MMP-1), while keratinocytes play a crucial role by producing epidermal cytokines ⁽⁶⁾. UVB-induced TNF- α release from keratinocytes and endothelial cells stimulates the production of elastases and collagenases, which damage and age the skin ⁽⁷⁾.

For the past 20 years, aesthetic clinicians and their patients have found that rejuvenating facial skin has become a very popular issue. Skin rejuvenation involves processes that remove aged or damaged layers and stimulate regeneration, leading to a restructured dermal matrix with more youthful characteristics, while restoring

epidermal function. A range of interventions has been employed to accomplish these outcomes, including chemical exfoliation, dermal fillers, laser-based therapies, botulinum toxin administration, and surgical lifting procedures ⁽⁸⁾.

Laser ablation has recently garnered interest due to its relatively shorter recovery time and notable efficacy versus other interventions. Laser ablation can be categorized as two types: ablative and non-ablative lasers. In general, ablative lasers are regarded as more efficacious for skin rejuvenation; though, they are associated with increased downtime and a higher incidence of undesirable effects, such as post-inflammatory hyperpigmentation, due to the greater thermal energy delivered to surrounding tissues ⁽⁸⁾. Given that individuals of Asian descent have a higher susceptibility to post-inflammatory hyperpigmentation, non-ablative lasers are often preferred, despite their comparatively slower and less pronounced results ⁽⁹⁾.

Non-ablative photo-rejuvenation methods target structural damage caused by photoaging without compromising the structure of the skin. These approaches induce controlled thermal injury, activating fibroblasts and promoting secondary collagen remodeling via modulation of heat shock proteins, vascular endothelial factors, and fibroblast growth factors. As a result, they stimulate the production of new collagen and extracellular matrix components, leading to dermal remodeling and improved skin firmness ⁽⁴⁾.

Laser light is defined by their specific wavelengths, being selectively taken up by the target tissues. Among non-ablative lasers, the long-pulsed Nd: YAG 1064 nm laser (LPND) is notable by capacity to transmit energy into the deep dermis, triggering controlled thermal injury which stimulates collagen and elastin regeneration without compromising the epidermis. As a result, this treatment improves skin laxity and elasticity, diminishes fine lines, and enhances general skin appearance, thereby promoting effective skin rejuvenation ⁽⁸⁾.

Among dermatological treatments, chemical peels are extensively used for the management of melasma, acne, scarring, and aging-related skin changes. Their mechanism involves keratolysis and cellular stimulation within the epidermis and dermis, promoting keratinocyte differentiation and neocollagenesis. Alpha-hydroxy acid (AHA)-based peels, particularly glycolic acid (GA), are prevalently applied due to their favorable safety profile, minimal downtime, and rapid efficacy. GA's small

molecular size and hydrophilic nature enable effective dermal penetration. Treatment protocols can be individualized through modification of GA concentration, pH, and period of exposure to achieve desired therapeutic outcomes ⁽¹⁰⁾.

The long-pulsed Nd: YAG 1064 nm laser stimulates collagen and elastin synthesis in the dermis through selective photothermolysis while maintaining epidermal integrity. This laser targets chromophores such as melanin, oxyhemoglobin, and water; yet, the uptake by melanin and oxyhemoglobin is lower compared to lasers operating in visible-light wavelengths. As a result, minimal energy is absorbed by the epidermis, decreasing the risk of adverse events, including blistering and eschar formation. Thus, the laser effectively targets deeper dermal chromophores, making it suitable for patients with darker pigmentation ⁽⁸⁾. In contrast, the topical application of 15% glycolic acid induces pronounced desquamation of the stratum corneum and markedly enhances keratinocyte proliferation in the epidermis, along with an intermediate increase in dermal collagen levels ⁽¹¹⁾.

The present study is designed to investigate the effects of combining the long-pulsed Nd: YAG 1064 nm laser with 15% glycolic acid for facial rejuvenation. Currently, no studies have been published assessing the effects of this combined treatment.

1.2 Research Questions

Is the combination treatment of long-pulsed Nd: YAG_{1064nm} laser with 15% glycolic acid effective for facial rejuvenation?

1.3 Objectives

1.3.1 General Objectives

To assess the effects of combination treatment of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid for facial rejuvenation.

1.3.2 Specific Objectives

1.3.2.1 Primary Objectives

To compare the mean changes of the overall improvement in Score of Global Aesthetic Improvement Scale of participants measured at 4th, 8th and 12th week.

1.3.2.2 Secondary Objectives

1. To compare the mean changes in wrinkle severity, skin viscoelasticity, and trans-epidermal water loss from baseline to weeks 4, 8, and 12, using Visioscan, Cutometer, and Tewameter measurements.
2. To assess the patient's satisfaction by using participants' satisfaction score.
3. To assess the adverse events of long-pulsed Nd: YAG 1064nm laser and glycolic acid combination treatment by using a research questionnaire.

1.4 Research Hypothesis

Combination therapy of long-pulsed Nd: YAG 1064nm laser with 15% glycolic acid is effective and safe for facial rejuvenation which will be assessed by the following:

1. Improving Physician Global Aesthetic Improvement Scale
2. Reducing wrinkles
3. Increasing viscoelasticity
4. Decreasing trans-epidermal water loss
5. Getting higher participants' satisfaction
6. Minimizing adverse events

1.5 Conceptual Framework

1.5.1 Concepts about Long-pulsed Nd: YAG 1064nm Laser for Facial Rejuvenation

Laser energy generates heat-induced injury in the dermis (up to 4mm depth) without ablating the epidermal layer. This damage is hypothesized to activate dermal

fibroblasts, inducing a healing response and resulting in improvements in skin quality (12).

1.5.2 Concepts about 15% Glycolic Acid for Facial Rejuvenation

Glycolic acid triggers sloughing of the outer epidermal layer by reducing cohesion within the stratum corneum. This effect is achieved through enhanced degradation of corneodesmosomes responsible for corneocyte adhesion. Additionally, glycolic acid has been shown to elevate levels of hyaluronic acid in both the epidermis and dermis, boost rates of keratinocyte and fibroblast proliferation, stimulate collagen production, and enhance the quality of elastic fibers ⁽¹¹⁾.

1.5.3 Concepts about Combination Treatment of Long-pulsed Nd: YAG 1064nm Laser and 15% Glycolic Acid for Facial Rejuvenation

Through the combination of long-pulsed Nd: YAG laser at 1064nm and 15% glycolic acid, the laser predominantly targets the dermis, induce collagen and elastin synthesis by selective photo-thermolysis. Glycolic acid is functioning as a superficial peel, primarily addresses the epidermis. It induces pronounced desquamation of the stratum corneum, markedly stimulates keratinocyte proliferation in the epidermis, and is accompanied by a moderate increase in collagen levels ⁽¹¹⁾. This dual approach is anticipated to yield reductions in wrinkles, enhance skin elasticity, and increase moisture.

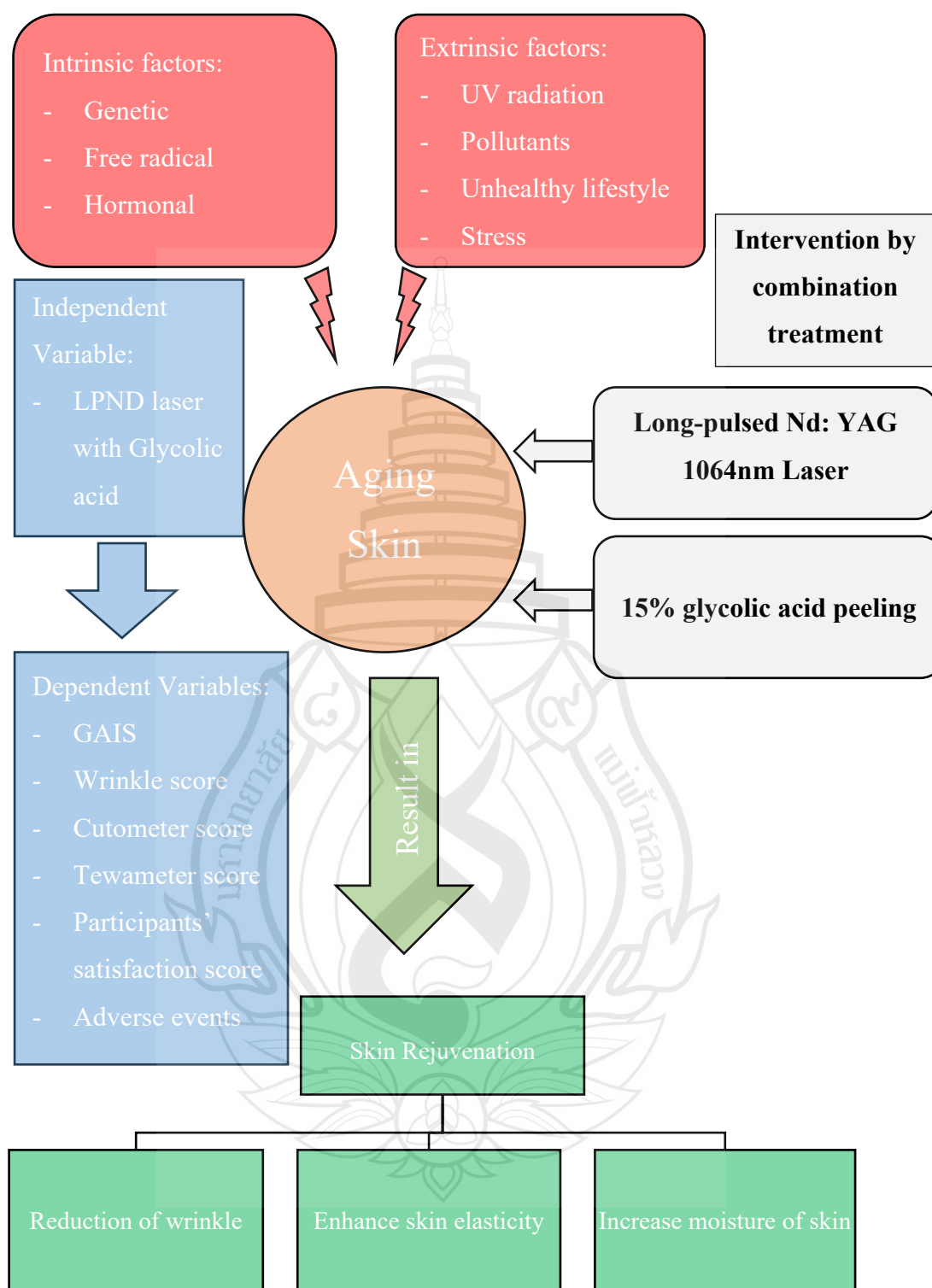


Figure 1.1 Conceptual framework

1.6 Scope of Research

The study included 15 male and female participants, aged 35 – 50, Fitzpatrick skin type III-V, who want to get facial rejuvenation. These participants will undergo a series of treatments by combination of long-pulsed Nd: YAG 1064nm laser with 15% glycolic acid at 4 weeks intervals for 3 times, 12 weeks periods at Mae Fah Luang University Hospital, Bangkok. Overall improvement is intended to be assessed by Physician Global Aesthetic Improvement Scale at 4th, 8th and 12th week. Assessment by VISIA® Complexion Analysis System, Cutometer and Tewameter will be done from baseline to each follow up visit (4th, 8th and 12th week). Participants' satisfaction will be assessed by Participant's Satisfaction Score at 12th week. All adverse events will be assessed at each follow-up visit.

1.7 Operational Definition

1.7.1 Physician Global Aesthetic Improvement Scale (GAIS)

Table 1.1 Physician global aesthetic improvement scale (GAIS)

Degree		Description
5	Marked improvement	Optimal aesthetic outcome achieved
4	Notable improvement	Significant improvement in appearance, though not fully optimal
3	Mild improvement	Moderate improvement compared with baseline; additional intervention recommended
2	Unchanged	Minimal or no change relative to baseline
1	Clinical worsening	Deterioration relative to baseline

1.7.2 Participant's Satisfaction Score

Table 1.2 Participant's satisfaction score

Grade	Degree
0	Not satisfied
1	Slightly satisfied
2	Moderately satisfied
3	Highly satisfied
4	Complete satisfaction

1.7.3 Fitzpatrick Skin Phototype

Table 1.3 Fitzpatrick skin phototype

Skin Type	Typical Features	Tanning Ability
I	Pale white skin, blue/green eyes, blonde/red hair	Always burns, does not tan
II	Fair skin, blue eyes	Burns easily, tans poorly
III	Darker white skin	Tans after initial burn
IV	Light brown skin	Burns minimally, tans easily
V	Brown skin	Rarely burns, tans darkly easily
VI	Dark brown or black skin	Never burn, always tans darkly

1.7.4 Effects

Effects include all noticeable or reported changes that arise from this combined treatment, covering both desired (therapeutic) and undesired (adverse) outcomes. In this study, effects mean improvement in GAIS, wrinkle score, viscoelasticity score and trans-epidermal water loss score and adverse events like pain, swollen, redness and hyper/hypopigmentation.

1.8 Limitation

Tissue biopsy will not be done due to volunteer's privacy and cosmetic concern.

CHAPTER 2

LITERATURE REVIEW

This research is designed to investigate the effects of combining long-pulsed Nd: YAG 1064 nm laser with 15% glycolic acid for facial rejuvenation. Thus, in this chapter, it will include literature review on

2.1 Skin anatomy and function

2.2 Natural course of facial aging

2.3 Procedure options for facial rejuvenation

2.4 Laser facial rejuvenation

2.5 Long-pulsed Nd: YAG 1064nm laser

2.6 Long-pulsed Nd: YAG 1064nm laser for facial rejuvenation

2.7 Glycolic acid for facial rejuvenation

2.8 Long-pulsed Nd: YAG laser in combination with glycolic acid for facial rejuvenation

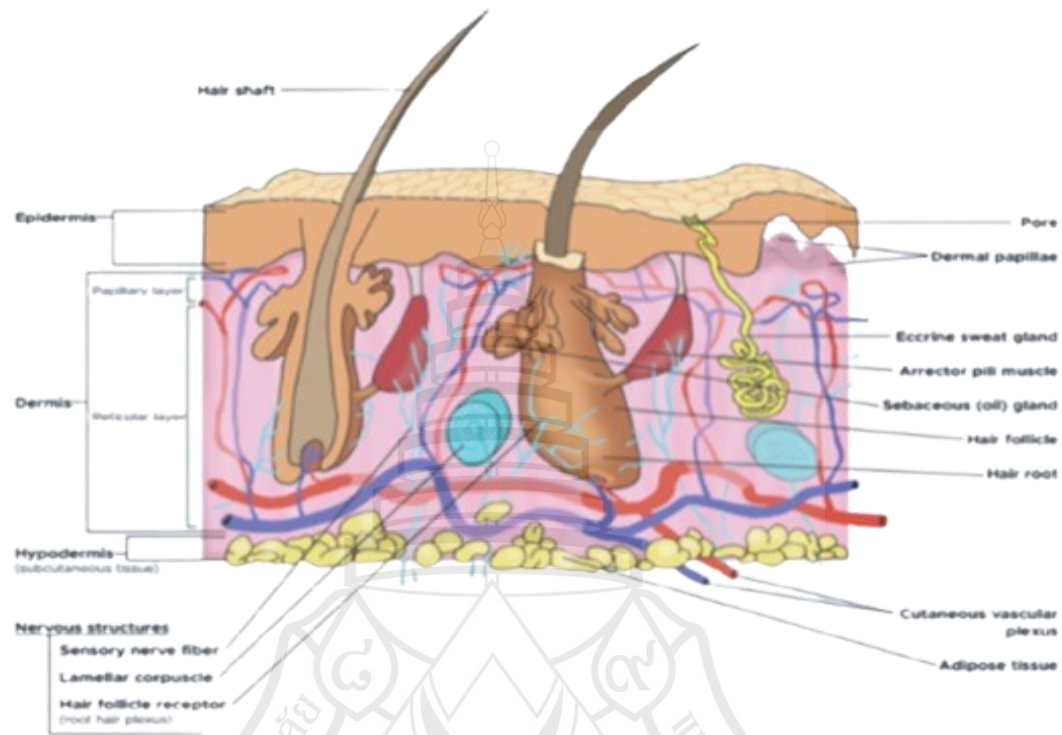
2.1 Skin Anatomy and Function

Human skin represents the body's largest organ system, enveloping the entirety of its external surface. Comprising three distinct layers; namely, the epidermis, dermis, and hypodermis; each layer possesses unique anatomical characteristics and fulfills specific physiological functions ⁽¹³⁾.

The epidermis is comprised of five layers housing various cell types, including keratinocytes, melanocytes (known as pigmented cells), langerhans cells (dendritic cells), and merkel cells (sensory cells). In contrast, the dermis, constituted by two layers of connective tissues, encompasses structures such as hair follicles, sweat glands, muscles, sensory neurons, blood vessels, and a network of collagen fibers ⁽¹⁴⁾.

The skin operates as the body's foremost defense, preventing the penetration of pathogens, blocking UV radiation, and resisting chemical insults, while offering mechanical resistance to external injuries. Beyond its protective role, the skin plays a

crucial part in thermoregulation and in modulating the release of water to the surrounding atmosphere ⁽¹³⁾.



Source ⁽¹⁴⁾

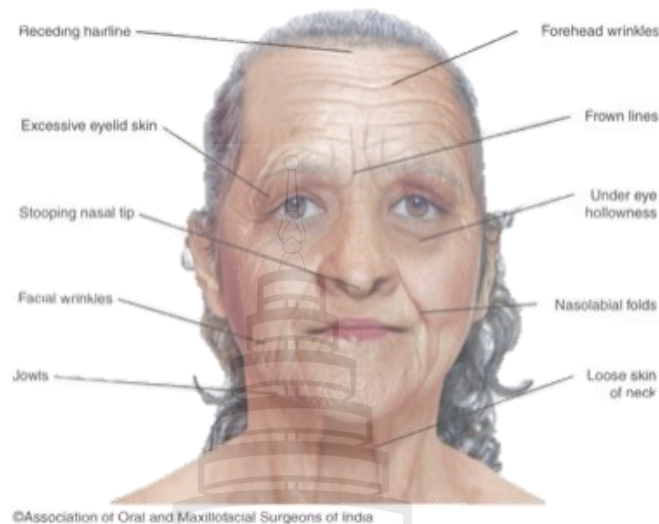
Figure 2.1 Cross section of layers of the skin

2.2 Natural Course of Facial Aging

The process of aging is inevitable and universal, characterized by intricate transformations over time, diminishing the youthful aspects of individuals. Facial manifestations of aging encompass the recession of the hairline, forehead wrinkles, upper eyelid drooping, under-eye hollowness, deepening of nasolabial folds, facial creases, and skin sagging along the mandibular border ⁽¹⁵⁾.

Intrinsic aging induces a general thinning of the skin, resulting in dryness, pallor, fine wrinkles, and diminished elasticity. Sweating and sebaceous gland functions decline, leading to reduced sebum secretion, ultimately causing dry skin. Concurrently, sebaceous gland hyperplasia may occur due to increased gland size.

Extrinsic aging, on the other hand, presents with coarse wrinkles, pronounced loss of elasticity, and dyspigmentation ⁽¹⁶⁾.



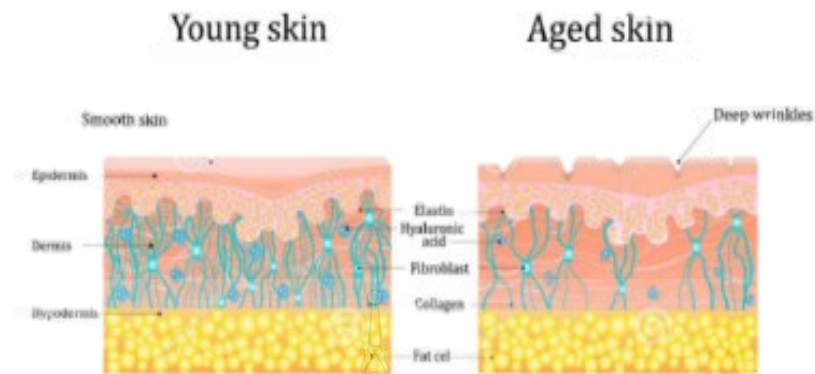
Source ⁽¹⁵⁾

Figure 2.2 Typical features of the aging face

2.2.1 Skin and Dermal Aging

The dermal layer of the skin is composed of collagen-rich connective tissue, imparting mechanical support and structural integrity. Fibroblasts within the dermis actively engage in synthesizing, organizing, and remodeling collagen, crucial for preserving the Extracellular Matrix (ECM) integrity ⁽¹⁶⁾.

A reduction in fibroblast leads to decrease collagen in dermis. A reduction in elastin leads to diminished elasticity, as elastin is responsible for maintaining the skin's flexibility. The decline in hyaluronic acid results in decreased moisture retention and compromised elasticity, given hyaluronic acid's role in moisturizing the skin and supporting its suppleness.



Source ⁽¹⁷⁾

Figure 2.3 Illustration comparing young versus aged skin, showing structural changes in collagen, elastin fibers, and fibroblasts

2.2.2 Subcutaneous Fat Distribution and Aging

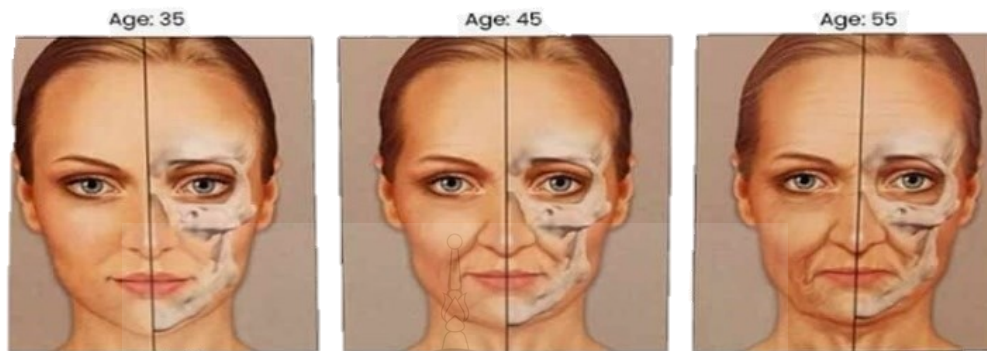
The aging process involves a redistribution of facial fat, characterized by a loss of fat in the forehead and cheeks and an accumulation of fat in the mouth and jaw areas. This shift in the pattern of fat pads leads to a noticeable change in the facial contour, creating deficiencies and empty spaces between fat pads, resulting in volume loss and altered facial contours ⁽¹⁸⁾.



Source ⁽¹⁹⁾

Figure 2.4 Schematic drawing of facial fat compartments demonstrating aging changes

2.2.3 Facial Bone and Aging



Source ⁽²⁰⁾

Figure 2.5 Bone changes according to age

The facial bony skeleton serves as the foundational support for overlying soft tissues, including muscles, subcutaneous fat, and skin. With advancing age, this framework undergoes progressive anatomical alterations, largely driven by post-adolescent degenerative and catabolic processes. Predictable patterns of bone resorption contribute significantly to the external manifestations of facial aging. The regions most susceptible to such resorptive changes include the periorbital area, midface, perinasal region, and mandibular structures ⁽¹⁵⁾.

2.3 Procedure Options for Facial Rejuvenation

2.3.1 Patients-directed

2.3.1.1 Sunscreen: plays a crucial role in minimizing both UVA and UVB absorption by the skin. Regular application of sunscreen with at least SPF 30 every 2 hours is recommended by the American Academy of Dermatology to prevent photodamage.

2.3.1.2 Moisturizers: including substances like petrolatum, dimethicone, and humectants, working as an occlusive film on the skin surface and facilitate the application of other skincare products.

2.3.1.3 Retinoids: derived from Vitamin A, exhibit the ability to enhance collagen production in the papillary dermis when topically applied.

2.3.1.4 Chemical peels : AHA, salicylic acid, and LHA, offer a superficial approach to skin rejuvenation.

2.3.1.5 Vitamins: vitamin E and C are capable of reducing erythema induced by ultraviolet radiation.

2.3.1.6 Cellular antioxidants like alpha-lipoic acid and ubiquinones, particularly coenzyme Q10, contribute to skincare by combating oxidative stress ⁽²¹⁾.

2.3.2 Physician-directed

2.3.2.1 Neuromodulators, specifically Botulinum Toxin A, are utilized for treating rhytides, glabellar lines, forehead lines, and bunny lines caused by focal muscle unit contractions. Notably, intradermal injection of botulinum toxin is now employed for addressing facial enlarged pores.

2.3.2.2 Fillers encompass a variety of soft tissue options, such as autologous fat, hyaluronic acid, Radiesse, Sculptra, and Artefill.

2.3.2.3 Chemical Peels include medium peels like TCA (35%) and combinations (Monheit's, Brody's, Coleman's), targeting photoaging and superficial atrophic scars. Deep peels, involving phenol, address pigmentary disorders, severe photoaging, and scars, albeit with a lengthier recovery time and more serious complications compared to superficial peels.

2.3.2.4 Microdermabrasion involves mechanical abrasion, stimulating dermal collagen and elastic fiber production.

2.3.2.5 Microneedling, also known as percutaneous collagen induction therapy, is employed for skin rejuvenation.

2.3.2.6 Ultrasound, delivered through focused ultrasound technology in the Ulthera® system, is applied to manage skin laxity caused by photoaging.

2.3.2.7 Radiofrequency selectively targets the dermis and subdermis, enhancing dermal collagen remodeling and synthesis.

2.3.2.8 Cryolipolysis represents a nonsurgical approach for localized adipose reduction and body reshaping.

2.3.2.9 Laser: ablative and non-ablative laser for skin resurfacing and rejuvenation ⁽²²⁻²³⁾.

2.4 Long-pulsed Nd: YAG 1064nm Laser

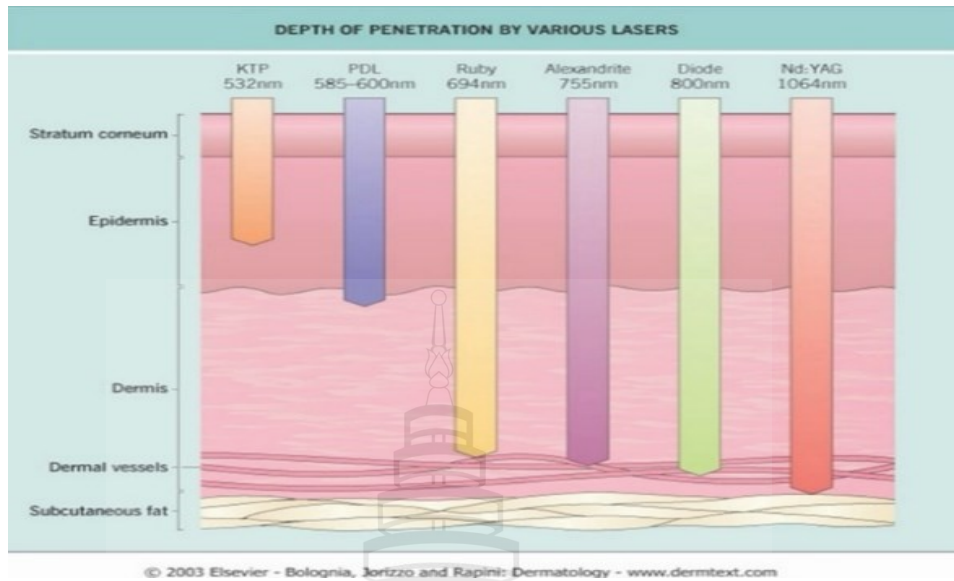
The Nd: YAG laser was among the earliest laser technologies, first introduced in 1964. Neodymium-doped yttrium aluminum garnet is a synthetic crystal capable of producing laser light in the near-infrared spectrum. The laser is generated by optically pumping the crystal with a high-intensity light source, such as a flashtube or diode, within an optical cavity that amplifies the emitted radiation. Efficient lasing requires the achievement of population inversion of the neodymium ions before activation ⁽²⁷⁾.

Nd: YAG lasers typically emit light across multiple wavelengths, including 1064, 940, 1120, 1320, and 1440nm, situated within the near-infrared region. Additionally, they commonly function using pulsed emission, employing Q-switching, as well as continuous mode ⁽²⁷⁾.

The Nd: YAG laser finds application in various medical fields, including laparoscopic surgery, gynecologic surgery, ophthalmology, and the treatment of cancerous tumors. It is employed in addressing mixed vulvovaginitis and pelvic floor dysfunction, encompassing issues like vaginal wall prolapse and diminished pelvic floor muscle tone. It is also used in laparoscopic surgery and gynecologic surgery ⁽²⁸⁾.

Furthermore, Nd: YAG laser is utilized in treating vascular conditions like port wine stain, hemangioma, and telangiectasia, along with applications in tattoo removal ⁽²⁹⁾. The Nd: YAG laser has been employed in aesthetic dermatology for procedures such as skin rejuvenation, skin tightening, and hair removal ⁽³⁰⁾.

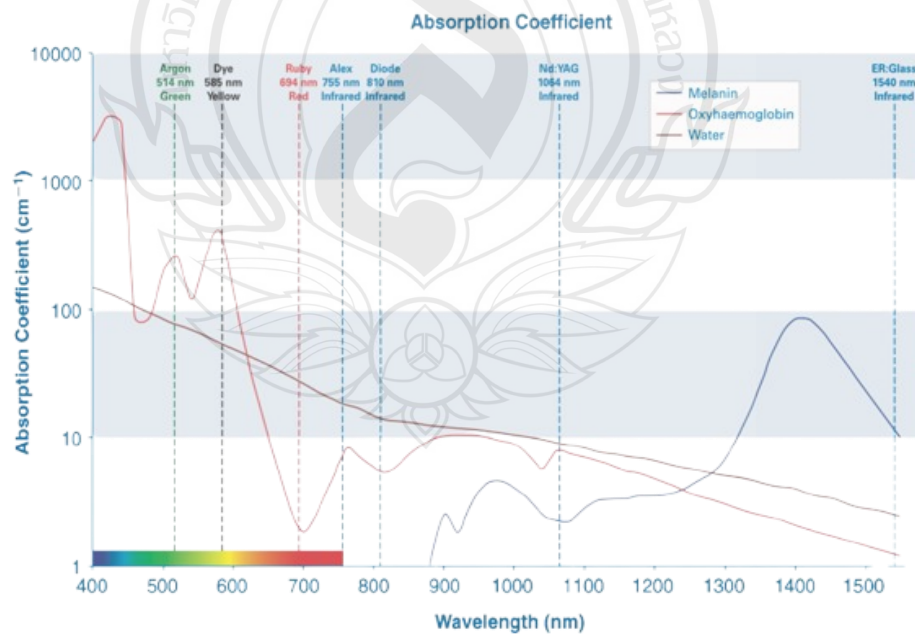
At 1064nm, Nd: YAG laser is capable of reaching a peak dermal penetration of more than 4 mm ⁽¹²⁾.



Source ⁽¹²⁾

Figure 2.6 Comparative penetration depths of different lasers

Chromophores are substances within tissues of human skin that absorb laser light, typically influencing the laser's therapeutic or cosmetic effects, such as melanin, hemoglobin, collagen, elastin, lipid and water.



Source ⁽³¹⁾

Figure 2.7 Absorption of chromophores — melanin, oxyhemoglobin and water — as a function of wavelength

The Nd: YAG laser at 1064nm has major skin chromophores comprising melanin, oxyhemoglobin, and water, in comparison with visible-spectrum lasers, its absorbance of melanin and oxyhemoglobin is less (Figure 2.7) ⁽¹²⁾.

Owing to its low melanin absorption, the 1064nm Nd: YAG laser deposits minimal energy within the epidermis, decreasing the incidence of side effects like blistering or eschar. This enables deeper tissue penetration and safe application in darker skin tones ⁽³²⁾.

2.6 Long-pulsed Nd: YAG 1064nm Laser for Facial Rejuvenation

As stated previously, the long-pulsed Nd: YAG 1064nm laser can penetrate to a depth greater than 4mm within the dermis. Via energy deposition within the deep dermis, the laser induces thermal injury, which in turn triggers the production and remodeling of collagen and elastin, whilst sparing the epidermis. This sequence of events contributes to enhanced skin laxity and elasticity, reduction of wrinkles, and improvement in overall skin tone, culminating in facial rejuvenation ⁽⁸⁾.

The heating process primarily affects the dermis through several mechanisms:

1. Bulk heating (photo thermolysis) directly damages collagen fibers through their absorption of energy.
2. Collagen fibers can also be damaged by conducted heat from chromophores in skin such as melanin and oxyhemoglobin.
3. Non-selective heating of the dermis initiates a cascade of regenerative processes, primarily involving collagen remodeling. This process is characterized by fibroblast proliferation and increased collagen synthesis, with remodeling activity beginning to rise approximately three weeks after laser exposure, continuing for up to five weeks, and reaching its peak around the fourth week. In addition to stimulating collagen production, dermal heating also promotes elastin regeneration, contributing to long-term stimulation of elastin fibers and overall improvement in skin structure and quality ⁽³³⁾.

Histological investigations by Tanaka et al. demonstrated rejuvenation-associated alterations at the dermal level following long-pulsed Nd: YAG 1064nm laser

resurfacing. These alterations included an increase in epidermal keratinocytes, collagen, elastin, and glycosaminoglycans. In addition, age-related dermal components, such as degenerated elastic connective tissues, were displaced during this remodeling process, further contributing to the rejuvenation effect ⁽³³⁾.

Studies conducted by Kaya et al. and Dayan et al. reported that the long-pulsed Nd: YAG 1064nm laser effectively improves skin laxity and reduces wrinkles, supporting its application in skin-tightening procedures ^(30, 34).

Key et al. explored the clinical effects of long-pulsed Nd: YAG laser treatment incorporating a skin temperature monitoring system. In their protocol, three sequential pulses were applied to each treatment site (parameters: 1064 nm wavelength, 12 mm spot size, 13 J/cm² fluence, 1 Hz repetition rate) without adjunctive cooling or anesthesia. Participants described only a gentle warming sensation, with no discomfort either during or following the procedure. Clinically, transient erythema was noted at treated sites, but edema was absent. Temperature recordings demonstrated a reproducible pattern of three incremental rises corresponding to each pulse, followed by a decline approaching baseline after the final exposure ⁽³⁵⁾.

2.7 Glycolic Acid for Facial Rejuvenation

Chemical peels are widely used by dermatologists worldwide to treat various skin conditions like melasma, acne, scars, and aging. They work by exfoliating the skin and stimulating cellular activity in both the epidermis and dermis, promoting keratinocyte differentiation and collagen production.

Alpha hydroxy acids (AHAs) are a group of chemical compounds commonly used as chemical peeling agents to address various skin concerns. They are organic acids characterized by a carboxylic group with a hydroxyl group on the neighboring carbon. AHAs are naturally present in various botanical sources such as fruits, and they can also be produced synthetically ⁽³⁶⁾.

Glycolic acid (GA), classified as an alpha-hydroxy acid (AHA), is widely utilized in dermatology owing to its favorable safety profile, minimal downtime, and rapid onset of clinical benefits. As a naturally occurring AHA with hydrophilic

properties and a relatively small molecular weight, GA readily penetrates the skin, enhancing its efficacy. Chemical peels using GA are highly adaptable, as the concentration, pH level, and application time can be adjusted to accommodate the specific therapeutic objectives and individual skin characteristics of each patient ⁽¹⁰⁾.

Several studies have reported that glycolic acid can be effectively employed as both a superficial and medium-depth peel in the clinical management of photoaged skin. Such chemical peeling procedures induce histological alterations within the epidermis, restoring a more organized architecture. Following treatment, columnar keratinocytes regain normal polarity, while melanocytes and melanin granules exhibit a more uniform distribution, contributing to improved epidermal morphology ⁽³⁷⁾.

The FDA recognizes glycolic acid as safe for dermatologic peeling procedures when applied in concentrations between 3% and 67% ⁽³⁸⁾. Topical application of glycolic acid (GA) at higher concentrations has been shown to promote keratinocyte desquamation and induce epidermolysis. This process facilitates increased cell turnover and stimulates collagen synthesis after exfoliation. Clinically, GA contributes to improved skin texture and tone, unclogging of pores, softening of fine lines and wrinkles, lightening of hyperpigmented lesions including photodamage, and enhanced hydration, thereby creating a more youthful appearance. In practice, dermatologists often employ GA as a relatively gentle resurfacing peel. Post-treatment downtime is minimal, with transient erythema or irritation being the most common effects, both of which can typically be concealed with cosmetics ⁽³⁹⁾.

Over the past decade, there has been a notable rise in the availability of cosmetic formulations containing alpha-hydroxy acids (AHAs). Glycolic acid, in particular, has been incorporated into a variety of topical agents, including keratolytics, moisturizers, and anti-aging products. Owing to the biological mechanisms that underly the cutaneous activity of AHAs, combined with frequent and prolonged application of these products to sun-exposed areas and anecdotal evidence of heightened photosensitivity, multiple clinical investigations have examined the influence of AHAs on ultraviolet sensitivity. Consequently, individuals undergoing glycolic acid treatment are advised to minimize sun exposure and consistently apply sunscreen when outdoors ⁽⁴⁰⁾.

Kubiak et al. conducted a comparative study evaluating the efficacy and safety of a combination peel consisting of 70% glycolic acid with 15% trichloroacetic acid

(TCA) versus a 35% TCA peel for the management of photoaged facial skin in women. Their findings indicated that the GA–TCA combination was well tolerated and did not produce significant adverse effects such as dryness, edema, or marked epidermolysis. Furthermore, the incidence of peel-induced erythema was not elevated by the addition of glycolic acid but was instead associated with the higher TCA concentration. Overall, the combined regimen was reported to be more comfortable and better tolerated compared with a 35% TCA peel alone ⁽³⁷⁾.

Narda et al stated that 15% glycolic acid showed strong effectiveness, significantly promoting desquamation, increasing keratinocyte proliferation, and enhancing collagen production without triggering inflammation. Overall, 15% GA at pH 4 was found to be an effective concentration for skin rejuvenation, balancing exfoliation and collagen stimulation while maintaining good tolerability and minimizing irritation ⁽¹¹⁾.

2.8 Combination of Long-pulsed Nd: YAG Laser and Glycolic Acid for Facial Rejuvenation

The long-pulsed Nd: YAG 1064nm laser promotes neocollagenesis and neoelastogenesis within the dermis via selective photothermolysis, while largely preserving epidermal integrity. Its primary chromophores include melanin, oxyhemoglobin, and water; however, the absorption coefficients for melanin and oxyhemoglobin at 1064nm are markedly lower compared to shorter, visible wavelengths. This reduced epidermal uptake attenuates thermal injury at the cutaneous surface, thereby minimizing the incidence of adverse sequelae such as vesiculation and eschar formation. Consequently, the laser energy penetrates more deeply to reach vascular and water-rich dermal targets, enabling efficacious remodeling of dermal architecture even in Fitzpatrick skin phototypes IV–VI, where epidermal melanin content would otherwise heighten the risk of complications with shorter-wavelength devices ⁽⁸⁾.

At a 15% concentration, glycolic acid promotes substantial stratum corneum desquamation, augments epidermal keratinocyte activity, and modestly elevates collagen levels ⁽¹¹⁾.

In a study by Vachiramon et al., the treatment of melasma in men with low-fluence Q-Switched Neodymium-Doped Yttrium-Aluminum-Garnet (LFQS Nd: YAG) laser versus a combination of the LFQS laser and 30% glycolic acid peeling was evaluated. This was a split-face, randomized controlled trial, where one side of the face received 5 weekly LFQS laser treatments, and the other side received LFQS treatment combined with 30% glycolic acid peeling. The results revealed that the combination therapy led to greater short-term improvements, with a 52% reduction in the Relative Lightness Index compared to 37.6% with laser treatment alone. Additionally, there was a 37.6% reduction in mMASI scores with combined therapy versus 14.6% with the laser alone at 4th week. Moreover, 61.5% of participants experienced over 75% clearance on the combined therapy side, while only 15.4% had similar results with laser treatment alone. Side effects such as burning and stinging were reported on both sides, but these were temporary, lasting no more than 12 hours, and required no additional treatment. Superficial skin peeling was also observed, which gradually improved over a few days with the application of 0.02% triamcinolone acetonide cream. One participant with Fitzpatrick skin type V experienced transient hyperpigmentation, which was resolved spontaneously within 3 months, while another participant with the same skin type developed permanent hypopigmentation ⁽⁴¹⁾.

In a study conducted by Park et al., a randomized, split face, observer-blinded trial was performed to evaluate the effectiveness and safety of combining a 1064nm Q-switched Nd: YAG laser with 30% glycolic acid peels versus laser monotherapy for treating melasma in adults with Fitzpatrick skin types III-V. Participants received six weekly sessions of laser on the entire face with 3 biweekly glycolic acid peels applied to one randomized side. The results demonstrated that the combination treatment side was more effective, leading to a greater reduction in Mexameter (32.6% vs 22%) and modified MASI scores (37.4% vs 16.7%) compared to laser treatment alone side. For participants' satisfaction, 75% rated combination treatment as good/excellent vs 38% for laser alone treatment. The study also indicated that the combination treatment was safe, although participants experienced mild, transient side effects such as erythema,

slight burning, and mild facial edema, all of which resolved within 3 hours. Superficial peeling was observed and managed with emollients, with no reports of permanent scarring or hypopigmentation ⁽⁴²⁾.



CHAPTER 3

RESEARCH METHODOLOGY

3.1 Study Design

This research is designed as an open-label, quasi-experimental clinical study. The intervention involves the application of a combination therapy using a long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid to the entire face, with outcomes evaluated by comparing pre- and post-treatment results.

3.2 Study Population

3.2.1 Subject Group

This study will recruit healthy adults, both male and female, aged 35–50 years, with Fitzpatrick skin type III-V who seek facial rejuvenation through a combined intervention of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid.

3.2.2 Sample

All subjects aged between 35 to 50 years with Fitzpatrick skin type III to V, who are willing to get treatment for facial rejuvenation with written informed consent. All participants are considered to meet the inclusion criteria and exclude from the exclusion criteria. This study will be performed at Mae Fah Luang University Hospital. Participants could make a follow-up visit at Mae Fah Luang University Hospital, Bangkok.

3.2.3 Calculation of Study Sample

For the purpose of estimating the sample size, reference data were obtained from a previously published study., “A quasi-interventional study on the efficacy of long pulsed Nd: YAG laser (LPND) in the treatment of periorbital wrinkles in a tertiary care hospital”. The mean Wrinkle Severity Score (WSS) by investigator is 3.18 ± 1.188 at baseline and 1.89 ± 1.031 at end of the treatment ⁽⁴³⁾.

According to the Winkle Severity Score,

$\alpha = 0.05$ (two-tailed), $Z_{\alpha/2} = Z_{0.025} = 1.96$

$\sigma = 1.031$

set $d = 0.6$

$$n = \frac{(Z_{\alpha/2})^2 \sigma^2}{d^2}$$

$$n = \frac{(1.96)^2 (1.031)^2}{(0.6)^2}$$

$$n = 11.3 = 12 \text{ participants}$$

Allowing an anticipated dropout rate of 20%, a total of 15 participants ($n=15$) will be recruited.

3.2.4 Selection Criteria

3.2.4.1 Inclusion Criteria

1. Healthy volunteers between 35 and 50 years of age with Fitzpatrick skin phototypes III to V
2. Volunteers who have manifestations of aging in the face like wrinkles, and reduced skin elasticity
3. Volunteers who are willing to receive treatment for facial rejuvenation with a long-pulsed Nd: YAG 1064 nm laser and 15% glycolic acid
4. Volunteers who provide consent and commit to attending all study visits
5. Volunteers who are available to come to Mae Fah Luang University Hospital, Bangkok

3.2.4.2 Exclusion Criteria

1. Women who are pregnant or currently breastfeeding
2. Individuals with skin conditions such as melasma or active skin infections
3. Individuals who have undergone dermabrasion or chemical peel treatments within the last 3 months
4. Individuals who have received energy-based devices (laser, HiFu, RF) or neurotoxin (botulinum toxin) within past 6 months

5. Individuals with a history of collagen or fat filler treatment in the preceding 9 months

6. Individuals who consume alcohol excessively, smoke, or misuse drugs

7. Individuals who are regularly exposed to sunlight for more than one hour per day or engage in tanning

8. Individuals undergoing topical therapy (retinol, bakuchiol, AHA, BHA, PHA) or systemic treatment (oral isotretinoin) likely to influence assessment results

3.2.4.3 Withdrawal Criteria

1. Subjects who decide to discontinue participation regardless of the reason

2. Subjects who get severe adverse reactions like skin irritation, excoriation, hypopigmentation or hyperpigmentation of the skin

3. Subjects who failed a follow-up visit during the study period

4. Early termination as lack of budget to conduct the project

5. Early termination as high number of subjects developing severe adverse reactions from study intervention

3.3 Study Location

Mae Fah Luang University Hospital, Bangkok.

3.4 Variables of the Study

3.4.1 Independent Variables

Long-pulsed Nd: YAG 1064nm laser with 15% glycolic acid

3.4.2 Dependent Variables

1. Global Aesthetic Improvement Scale

2. VISIA® Complexion Analysis System for wrinkle score

3. Cutometer® MPA 580 score

4. Tewameter® TM 300 score
5. Participant's Satisfaction Score
6. Adverse events

3.5 Research Instruments

- 3.5.1 Participant information sheet
- 3.5.2 Informed consent form
- 3.5.3 Doctor record form
- 3.5.4 Clinical evaluation record form
- 3.5.5 Participant's satisfaction form
- 3.5.6 Hyperion laser (LASEROPTEK, Korea)
- 3.5.7 15% glycolic acid liquid from Skin Intimate Company
- 3.5.8 VISIA® Complexion Analysis System
- 3.5.9 Cutometer® MPA 580
- 3.5.10 Tewameter® TM 300

3.6 Equipment

3.6.1 Hyperion® Laser System



Source ⁽⁴⁴⁾

Figure 3.1 Hyperion® (LASEROPTEK, Korea)

Table 3.1 Device characteristics: Hyperion® laser

Device Specifications: Hyperion® Laser	
Type of Laser	Nd: YAG
Operating Wavelength	1064 nm
Range of Pulse Duration	0.3 ms – 300 ms
Maximum Pulse Energy	80 J
Pulse Repetition Frequency	SIG, 1 to 10 Hz
Adjustable Spot Size	2 to 20 mm
Integrated Cooling Mechanism	Closed cycle water to air heat exchange
Power Supply Requirements	220 – 230 V, 50/60 Hz

Source ⁽⁴⁴⁾

In this research, we will employ the HYPERION Laser (manufactured by LASEROPTEK, Korea). The HYPERION laser is a long-pulsed Nd: YAG laser with a wavelength of 1064nm. Its features enhance laser stability and beam homogeneity, resulting in better results, fewer complications with quicker healing for hair removal in persons with Fitzpatrick Skin Types IV-VI, vascular lesions, and skin rejuvenation treatments.

3.6.2 15% Glycolic Acid

In this study, 15% glycolic acid solution is studied for its efficacy for facial rejuvenation. It is manufactured by Skin Intimate company.

Table 3.2 Process outline for 15% glycolic acid preparation

No.	Phase	INCI (Standard English Name)	% in formula	% in Material	Function	Explanation*
1.	A	Deionized water	73.300	100.000	Solvent	Clear liquid
2.		Glycolic acid	15.000	100.000	Skin conditioning	White powder
3.	B	Glycerin	3.000	100.000	Humectant	Clear liquid
4.		Phenoxyethanol	0.700	65.000	Preservatives	Clear liquid
		Chlorphenesin		25.000		
		Glycerin		10.000		

Table 3.2 (continued)

No.	Phase	INCI (Standard English Name)	% in formula	% in Material	Function	Explanation*
5.	C	Aminomethyl Propanol	8.000	100.00	pH Adjuster	Clear liquid
Total			100.000			
	Color	Transparent or not	Texture (liquid/ Emulsion/ Cream/ Powder/ Solid stick)			
	Colorless	Clear to light yellow	Liquid			

Note Process descriptions:

1. Mixed components A (1,2)
2. Mixed components B (3,4), then mixing with component no. (B—A)
3. Add part B into part A, mix Stirrer until homogenous texture
4. Add part C into part AB mix stirrer until homogenous texture

3.6.3 The VISIA® Complexion Analysis System

Developed by Canfield (Fairfield, NJ), the VISIA® Complexion Analysis System is designed for comprehensive facial scanning, utilizing multi-spectral imaging to record and evaluate essential skin features data.

This system detects various aspects of skin complexion and facial characteristics, analyzing spots, wrinkles, textural changes, pore visibility, ultraviolet spots, pigmented (brown) areas, vascular (red) regions, and porphyrins, all within an uniform setting.



Source (45)

Figure 3.2 The VISIA® Complexion Analysis System

3.6.4 Cutometer® MPA 580



Source (46)

Figure 3.3 Cutometer® MPA 580

The Cutometer evaluates the elasticity of the superficial skin layer by applying negative pressure through a suction mechanism. This method allows for the assessment of the skin's elastic and mechanical characteristics, offering an objective measure of skin aging.

3.6.5 Tewameter® TM 300

Utilizing the “open chamber” principle, the Tewameter® TM 300 stands as the most globally utilized device for evaluating trans-epidermal water loss (TEWL). It serves as a crucial parameter in assessing the skin's moisture barrier function, fundamental across various applications. This device can detect even subtle damage to the skin's moisture barrier in its early stages.



Source ⁽⁴⁷⁾

Figure 3.4 Tewameter® TM 300

3.6.6 KOOLIO Machine

KOOLIO is an advanced air-cooling system specifically designed to cool the skin before, during, and after laser procedures. It helps minimize pain and lowers the risk of thermal damage during or after the laser treatment, as well as providing temporary relief from topical anesthetic injections.



Source ⁽⁴⁸⁾

Figure 3.5 KOOLIO machine (DAOL MED)

3.7 Study Procedures

3.7.1 Recruitment of Volunteers

Volunteers will be recruited according to inclusion and exclusion criteria.

3.7.2 Explanation about Research

Volunteers will be given explanations of the aim of research, procedure steps, anticipated benefits and possible adverse effects of the treatment to each volunteer.

3.7.3 Process of Acquiring Informed Consent

All volunteers will be required to provide written informed consent prior to participation in the trial.

3.7.4 Medical History Assessment

General information such as age, sex, occupation, and past medical history relevant to this research will be obtained from the volunteers.

3.7.5 Procedural Framework for Intervention

All subjects will be evaluated using the Visioscan, Cutometer, and Tewameter. To standardize conditions, participants will first wash their face with mild soap and wait 15 minutes for natural drying in a controlled environment prior to measurement or treatment.

3.7.5.1 Facial Photography of Participants

Standardized facial photographs will be acquired for all participants using the VISIA® Complexion Analysis System at baseline and at weeks 4, 8, and 12. Images will be taken under controlled conditions, including switching-off room lighting, a 12-megapixel resolution setting, automatic white balance correction, and autofocus. Each participant's face will be imaged at three angles: right 45°, left 45°, and frontal (0°). All images will be anonymized using coded identifiers, and participants' eyes will be concealed to maintain anonymity.

3.7.5.2 Measurement of Skin Elasticity via Cutometer

The Cutometer® MPA 580 was used to assess skin elasticity at baseline, and subsequently at weeks 4, 8, and 12. Data were collected from the right and left cheek areas as well as from both sides of the forehead.

3.7.5.3 Measurement of Trans-epidermal Water Loss Using Tewameter

Tewameter® TM 300 was employed to record trans-epidermal water loss at baseline, and subsequently at weeks 4, 8 and 12, as an indicator of skin moisture levels. Data were collected from both the right and left sides of the cheek and forehead.

According to the Courage + Khazaka electronic GmbH(2023), we will set the room temperature between 20-22 °C and room humidity will be set between 40-

60%. All participants will be measured 15 minutes post face wash and participants will be asked to sit in the room with a set temperature and humidity as mentioned above for 15 minutes.

3.7.5.4 Application of Anesthetic Cream

Topical anesthetics, EMLA cream (lidocaine 2.5% and prilocaine 2.5%), will be applied and left for 30 minutes. Before the procedure, the cream will be cleaned off.

3.7.5.5 Application of 15% Glycolic Acid

Topical petroleum jelly will be applied around the eyes, mouth and nasal folds to provide moisture and prevent irritation during the procedure.

Glycolic acid 15% liquid (1 cc) will be soaked in a cotton pad and was distributed evenly over the face, avoiding the periocular region, allowed to remain for 2 minutes, prior to rinsing with water.

3.7.5.6 Application of Hyperion Laser

Treatment was performed with the Hyperion Laser, a long-pulsed Nd: YAG laser, using parameters of 1064 nm wavelength, 5 mm spot size, 0.3 ms pulse duration, 15 J/cm² fluence, and 10 Hz frequency with the red handpiece (2, 3, 5 mm). Three passes were administered per session, totaling 1000–2000 shots distributed across the cheeks, forehead, chin, and T-zone.

According to the device manufacturer's recommendations, the laser handpiece was maintained at an approximate distance of 2 cm from the face and guided smoothly over the target regions. Scanning was performed in both horizontal (left–right) and vertical (top–down) directions to ensure uniform coverage. If discomfort occurred, the handpiece was repositioned slightly farther from the surface and the movement speed was increased. Protective eyewear was worn by all participants throughout the procedure. This session will last for 20-30 minutes.

To reduce the adverse events of this combined therapy, the KOOLIO cooling device will be utilized throughout the laser treatment. The temperature will be set at -30°C.

3.7.5.7 After-Treatment Instructions

Following treatment, participants were instructed to apply sunscreen with a minimum sun protection factor of 30 and to avoid direct exposure to sunlight. The use

of personal skincare products was allowed for participants but advice to avoid skin care products that contain AHA, BHA, PHA, TCA, retinol and bakuchiol to prevent them posing any risk to the participants and to prevent the products interfering with the assessment. Complications following treatment, including pain, swelling, burning, or other side effects, were monitored and recorded.

3.8 Follow-up Assessments

Participants returned for follow-up evaluations at weeks 4, 8, and 12. In each visit, facial imaging was performed with the VISIA® Complexion Analysis System using identical technical settings to baseline. Skin elasticity and TEWL were examined at all follow-up points using the Cutometer® MPA 580 and Tewameter® TM 300, respectively. The Physician Global Aesthetic Improvement Scale (GAIS) was recorded at weeks 4, 8, and 12, while satisfaction ratings were obtained from participants at week 12. Any treatment-related adverse events were systematically monitored and documented throughout the follow-up period.

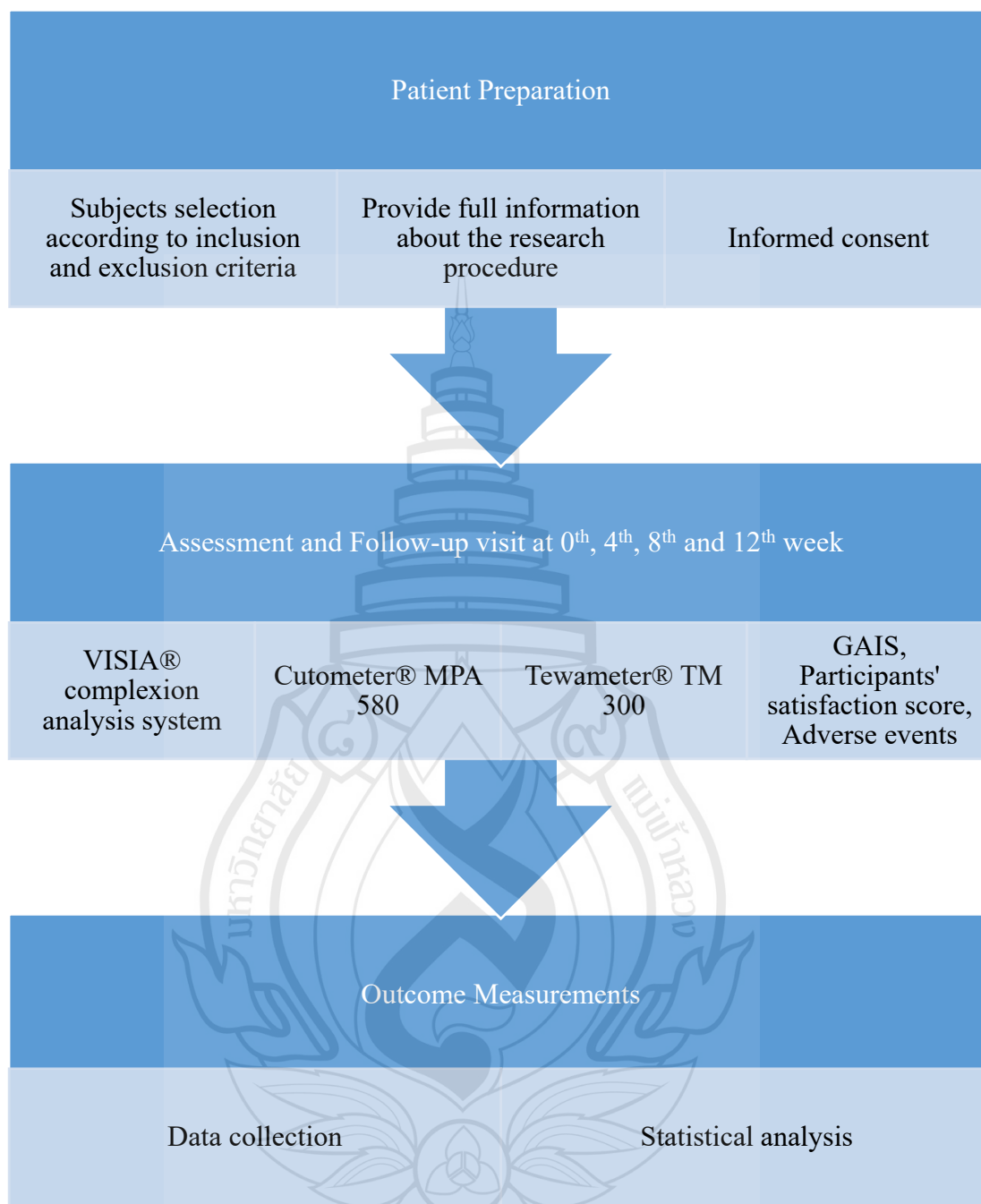


Figure 3.6 Steps of research

3.9 Data Collection

3.9.1 Participants' demographic details were recorded as part of the initial history taking.

3.9.2 Participants' overall improvement was assessed at weeks 4, 8, and 12 through photographs taken with VISIA® complexion imaging. Three Dermatologists will determine the level of improvement by using Physician Global Aesthetic Improvement Scale (GAIS) comparing the baseline photographs with those taken at 4th, 8th and 12th weeks respectively.

3.9.3 Wrinkle analysis was conducted using the VISIA® Complexion Analysis System at baseline and at follow-up intervals of 4, 8, and 12 weeks.

3.9.4 Assessment of skin elasticity was conducted with the Cutometer® MPA 580 at baseline and at follow-up visits on weeks 4, 8, and 12.

3.9.5 Trans-epidermal water loss was recorded with the Tewameter® TM 300 at baseline and at follow-up visits on weeks 4, 8, and 12.

3.9.6 A satisfaction score was obtained from participants at week 12 using a predefined grading system.

3.9.7 All adverse events were assessed at baseline and at the 4th, 8th, and 12th week follow-up visits through participant interviews and clinical observations.

1. Pain intensity was recorded using a numerical rating scale (0-10).
2. The duration of erythema, swollen, bruise was documented
3. Other potential adverse events, including post-inflammatory hyperpigmentation, hypopigmentation, infection, ulceration, and scar formation, were assessed.

3.10 Outcome Measurements

3.10.1 Measurement of Primary Outcomes

To evaluate the differences in mean values of the overall improvement in Score of Global Aesthetic Improvement Scale of participants assessed at 4th, 8th and 12th week.

3.10.2 Measurement of Secondary Outcomes

3.10.2.1 To evaluate the differences in mean values of wrinkle scores, skin viscoelasticity, and trans-epidermal water loss score between baseline and weeks 4, 8, and 12, using data obtained from the Visioscan, Cutometer, and Tewameter.

3.10.2.2 To assess the participants' satisfaction by the participant's satisfaction score.

3.10.2.3 To evaluate potential adverse events of long-pulsed Nd: YAG laser combined with glycolic acid therapy, structured questionnaires will be utilized.

3.11 Data Analysis

Data, including participants' medical records and study outcomes, were documented using Microsoft Excel 2021 and analyzed with SPSS (IBM, version 2.1.0), under renewal quote number 26,500,879 from Mae Fah Luang University, Chiang Rai, Thailand.

3.11.1 Descriptive Statistics

3.11.1.1 Descriptive statistical methods were applied to summarize participants' demographic data as well as wrinkle, skin elasticity, and trans-epidermal water loss scores and adverse events.

3.11.1.2 Physician GAIS scores at weeks 4, 8, and 12 were analyzed descriptively.

3.11.1.3 Descriptive statistical techniques were applied to evaluate participants' satisfaction scores at week 12.

3.11.1.4 Descriptive statistical analysis will be analyzed into means and standard deviations.

3.11.2 Inferential Statistics

3.11.2.1 Repeated-measures ANOVA was performed to evaluate statistical significance of mean value differences in GAIS scores across weeks 4, 8, and 12.

3.11.2.2 Repeated-measures ANOVA was applied to assess statistical significance of mean value differences in wrinkle scores, skin viscoelasticity, and trans-epidermal water loss across baseline and follow-up time points.

3.11.2.3 Adverse events at baseline, 4th, 8th and 12th week will be compared by Cochran's Q test.

3.11.2.4 A p-value of less than 0.05 was considered statistically significant

3.12 Ethical Aspects of the Study

The present study was designed and implemented in compliance with the principles of Good Clinical Practice (GCP), the internationally recognized standard for the ethical and scientific conduct of human clinical research. Approval for the study was obtained from the Human Research Ethics Committee of Mae Fah Luang University, ensuring that all procedures adhered to ethical requirements for safeguarding participants' rights, safety, and welfare.

A thorough risk–benefit assessment was performed as part of the study protocol to justify the involvement of participants, with their well-being considered paramount and prioritized above scientific or academic objectives. Before enrollment, each participant was fully informed about the study procedures and provided written informed consent. Strict confidentiality of data was maintained throughout the research process, and no personal identifiers were included in the reported findings. Any side effects, discomfort, or concerns experienced during treatment were promptly addressed and documented to reduce participant anxiety and ensure their safety and comfort.

Participants benefitted from receiving a novel combination treatment involving long-pulsed Nd: YAG laser therapy with a 15% glycolic acid peel for facial rejuvenation. Both treatment modalities have been previously studied and shown to be safe and effective, and in this trial, all procedures were conducted under professional supervision in a hospital environment. The study also provided an opportunity to evaluate the potential of this combination therapy to enhance collagen remodeling and skin rejuvenation while reducing discomfort. The outcomes are expected to contribute meaningful evidence to dermatological research and provide a foundation for further studies by future investigators.

CHAPTER 4

RESULTS

4.1 Participant Demographics

Table 4.1 Demographic characteristics: Descriptive analysis

Demographic Data	n=15
Biological sex, n(%)	
Male	5
Female	10
Chronological age (years)	
Mean±SD	38.19±4.09
Underlying disease, n(%)	
No	15
History of Allergy, n(%)	
No	15
Fitzpatrick Skin Type	
I	0
II	0
III	9
IV	4
V	2
VI	0

Table 4.1 presents the demographic information of the 15 participants, comprising 10 females and 5 males. The average age was 38.19±4.09. None of them had any underlying health conditions or a history of allergies. There were 9 participants with Fitzpatrick skin type III, 4 participants with Fitzpatrick skin type IV and 2 participants with Fitzpatrick skin type V.

4.2 Clinical Evaluation

4.2.1 Physician Global Aesthetic Improvement Scale (GAIS)

Table 4.2 Physician GAIS scores: Statistical evaluation at 4th, 8th, and 12th week follow-ups (n=15)

Follow-up	Mean±SD
4 th week	3.4±0.51
8 th week	4.3±0.46
12 th week	4.8±0.41
P-value	<0.001

Note Repeated-measures ANOVA was applied for data analysis.

Statistical significance was defined as $p < 0.05$.

In accordance with Table 4.2, which presents the statistical analysis of the Global Aesthetic Improvement Scale (GAIS), the mean GAIS scores at weeks 4, 8, and 12 were 3.4 ± 0.51 , 4.3 ± 0.46 , and 4.8 ± 0.41 , respectively. A statistically significant increase in mean GAIS scores was observed at each follow-up ($p < 0.001$, partial $\eta^2 = 0.832$). This means that 83.2% of the changes in GAIS scores were due to the effect of the combined LPND laser and glycolic acid treatment.

Table 4.3 Multiple post-hoc analysis of GAIS outcomes (n=15)

Pairwise	Mean difference	P-value
4 th week – 8 th week	-0.87	<0.001
4 th week – 12 th week	-1.4	<0.001
8 th week – 12 th week	-0.53	0.002

Note Statistical analysis was performed with the Bonferroni method

Mean differences reaching $p < 0.05$ were statistically significant

Multiple comparisons (Table 4.3) indicated that GAIS scores at weeks 8 and 12 were significantly higher than at week 4, with week 12 also higher than week 8 ($p < 0.05$). Overall, GAIS scores increased by 1.4 points from week 4 to week 12.

4.2.2 Wrinkle Score by VISIA

Table 4.4 Wrinkle scores: statistical evaluation at baseline, 4th, 8th, and 12th week follow-ups (n=15)

Follow-up	Mean±SD
Baseline	57.51±14.01
4 th week	44.80±14.81
8 th week	32.23±8.60
12 th week	22.48±7.74
P-value	<0.001*

Note Repeated-measures ANOVA was applied for data analysis.

Statistical significance was defined as $p < 0.05$.

In accordance with Table 4.4, which presents the statistical analysis of wrinkle scores, the mean scores at baseline, week 4, week 8, and week 12 were 57.51 ± 14.01 , 44.80 ± 14.81 , 32.23 ± 8.60 , and 22.48 ± 7.74 , respectively. A statistically significant reduction in wrinkle scores was observed at each follow-up ($p < 0.001$, partial $\eta^2 = 0.8303$). This means that 83% of the changes in wrinkle scores were due to the effect of the combined LPND laser and glycolic acid treatment.

Table 4.5 Multiple post-hoc analysis of wrinkle score outcomes (n=15)

Pairwise	Mean difference	P-value
Baseline – 4 th week	12.71	0.027
Baseline – 8 th week	25.28	<0.001
Baseline – 12 th week	35.03	<0.001
4 th week – 8 th week	12.56	0.010
4 th week – 12 th week	22.32	<0.001
8 th week – 12 th week	9.754	0.004

Note Statistical analysis was performed with the Bonferroni method

Mean differences reaching $p < 0.05$ were statistically significant

Multiple comparisons (Table 4.5) showed that whole-face wrinkle scores demonstrated significant reductions at weeks 4, 8, and 12 versus baseline. Scores at

weeks 8 and 12 were also significantly lower than at week 4, with week 12 further reduced compared to week 8 ($p < 0.05$). Overall, scores decreased by 35.03 points from baseline to Week 12.

4.2.3 Cutometer Score

Table 4.6 Cutometer scores: Statistical evaluation at baseline, 4th, 8th, and 12th week follow-ups (n=15)

Follow-up	Mean±SD
Baseline	54.10±10.96
4 th week	66.76±8.83
8 th week	80.80±8.35
12 th week	88.58±7.43
P-value	<0.001*

Note Repeated-measures ANOVA was applied for data analysis.

Statistical significance was defined as $p < 0.05$.

In accordance with Table 4.6, which presents the statistical analysis of cutometer scores, the mean scores at baseline, week 4, week 8, and week 12 were 54.10±10.96, 66.76±8.83, 80.80±8.35, and 88.58±7.43, respectively. A statistically significant increasing in cutometer scores was observed at each follow-up ($p < 0.001$, partial $\eta^2 = 0.826$). This means that 82.6% of the changes in cutometer scores were due to the effect of the combined LPND laser and glycolic acid treatment.

Table 4.7 Multiple post-hoc analysis of cutometer score outcomes (n=15)

Pairwise	Mean difference	P-value
Baseline – 4 th week	-12.66	0.002
Baseline – 8 th week	-26.70	<0.001
Baseline – 12 th week	-30.35	<0.001
4 th week – 8 th week	-14.04	<0.001
4 th week – 12 th week	-17.69	<0.001
8 th week – 12 th week	-7.78	0.015

Note Statistical analysis was performed with the Bonferroni method

Mean differences reaching $p < 0.05$ were statistically significant

Multiple comparisons (Table 4.7) indicated that cutometer score demonstrated significant improvement at weeks 4, 8, and 12 versus baseline. Scores at weeks 8 and 12 were significantly higher than at week 4, with week 12 exceeding week 8 ($p < 0.05$). Overall, scores increased by 30.35 points from baseline to week 12.

4.2.4 Tewameter Score

Table 4.8 Tewameter scores: statistical evaluation at baseline, 4th, 8th, and 12th week follow-ups (n=15)

Follow-up	Mean±SD
Baseline	19.23±4.01
4 th week	15.89±2.79
8 th week	13.85±1.95
12 th week	10.34±2.02
P-value	<0.001

Note Repeated-measures ANOVA was applied for data analysis.

Statistical significance was defined as $p < 0.05$.

In accordance with Table 4.8, which presents the statistical analysis of tewameter scores, the mean scores at baseline, week 4, week 8, and week 12 were 19.23±4.01, 15.89±2.79, 13.85±1.95, and 10.34±2.02, respectively. A statistically significant reduction in tewameter scores was observed at each follow-up ($p < 0.001$, partial $\eta^2 = 0.838$). This means that 83.8% of the changes in tewameter scores were due to the effect of the combined LPND laser and glycolic acid treatment.

Table 4.9 Multiple post-hoc analysis of tewameter score outcomes (n=15)

Pairwise	Mean difference	P-value
Baseline – 4 th week	3.34	0.016
Baseline – 8 th week	5.37	<0.001
Baseline – 12 th week	8.89	<0.001
4 th week – 8 th week	2.03	0.033
4 th week – 12 th week	5.55	<0.001
8 th week – 12 th week	3.51	<0.001

Note Statistical analysis was performed with the Bonferroni method

Mean differences reaching $p < 0.05$ were statistically significant

Multiple comparisons (Table 4.9) indicated that tewameter scores demonstrated significant reductions at weeks 4, 8, and 12 versus baseline. Scores at weeks 8 and 12 were significantly lower than at week 4, with week 12 showing further reduction compared to week 8 ($p < 0.05$). Overall, scores decreased by 8.89 points from baseline to week 12.

4.2.5 Participant's Satisfaction Score

Table 4.10 Frequency of participant's satisfaction score

Participant's Satisfaction Score	n=15
Not satisfied (0)	-
Slightly satisfied (1)	-
Moderately satisfied (2)	-
Highly satisfied (3)	5
Complete satisfaction (4)	10

As shown in Table 4.10, which presents the frequency distribution of participant's satisfaction scores, 10 participants reported being "complete satisfaction", while 5 participants reported being "highly satisfied".

4.2.6 Adverse Events

No adverse events were reported among the 15 participants throughout the study. Specifically, none of the participants experienced pain, erythema, hyperpigmentation, hypopigmentation, or any other side effects following the treatment. This suggests that the combined LPND laser and glycolic acid intervention was well tolerated and demonstrated a favorable safety profile.

CHAPTER 5

DICUSSION AND CONCLUSION

5.1 Discussion

This study evaluated the effects of combination treatment of long-pulsed Nd: YAG 1064nm laser with 15% glycolic acid for facial rejuvenation. 15 participants aged 35–50 years with Fitzpatrick skin types III–V were participated in this study. All participants underwent 3 treatment sessions at four-week intervals with a combination of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid. Multiple parameters including Physician Global Aesthetic Improvement Score (GAIS), wrinkle score, skin elasticity score, trans-epidermal water loss score, participant's satisfaction score and adverse events were used to assess the effectiveness and safety of this study.

GAIS scores are evaluated by 3 dermatologists using photographs taken by the VISIA® Complexion Analysis System at weeks 4, 8 and 12. The results demonstrated a significant and progressive improvement in GAIS scores across all follow-up visits.

Wrinkle scores measured by VISIA showed a significant decline from baseline to week 12. These findings align with the known mechanisms of glycolic acid, which enhances epidermal turnover and improves surface texture ⁽¹¹⁾, and long-pulsed Nd: YAG laser, which stimulates dermal collagen synthesis ⁽⁸⁾.

Skin elasticity score was measured by Cutometer® MPA 580. The results indicated a statistically significant increase in skin elasticity, reflecting improved dermal structure and firmness.

TEWL was measured by Tewameter® TM 300 which showed progressive reduction, suggesting enhanced barrier function and hydration of the skin. These objective findings collectively confirm that the dual treatment addressed both surface-level and deeper signs of skin aging.

Patient satisfaction was notably high, with 5 participants reporting “complete satisfaction” and 10 participants reporting “highly satisfied”.

Importantly, no adverse events including pain, erythema, hyperpigmentation, hypopigmentation were reported throughout the study, suggesting an excellent safety profile.

These results are consistent with prior research showing the individual benefits of Nd: YAG laser or glycolic acid peels.

Key et al. reported that a single treatment session with long-pulsed Nd: YAG laser produced a significant improvement in skin laxity ⁽³⁵⁾. Similarly, another study demonstrated significant reductions in both facial wrinkles and laxity following Nd: YAG treatment ⁽³⁴⁾. Histological evidence further supports these findings, showing that long-pulsed Nd: YAG laser induces collagen formation within the reticular dermis, thereby providing an effective modality for facial rejuvenation ⁽³⁴⁾.

In a split-face trial, Hong et al. employed long-pulsed Nd: YAG laser with a pulse duration of 12ms and fluence of 20–24 J/cm² and observed significant clinical improvement in wrinkle reduction and skin elasticity on the treated side at each follow-up visit. Histological assessment in that study confirmed a marked increase in collagen fibers and elastin content in the treated areas ⁽⁸⁾.

Previous studies have demonstrated that glycolic acid at concentrations of 70% can significantly improve pigmentation and photoaging ⁽³⁹⁾, and also lower concentrations ranging from 8% to 25% (adjusted to pH 4) have been shown to induce epidermal desquamation, enhance epidermal renewal, and stimulate dermal collagen production ⁽¹¹⁾.

This present study demonstrated that the combination of long-pulsed Nd: YAG 1064nm laser with 15% glycolic acid is also effective for facial rejuvenation. While earlier studies have confirmed the efficacy of Nd: YAG laser in improving skin laxity, wrinkles, and dermal collagen remodeling ^(8, 34, 36, 49), and glycolic acid in enhancing epidermal turnover and improving photoaging ^(36, 41), our results suggest that combining these two modalities are also effective in facial rejuvenation. In the current trial, participants exhibited significant improvements in GAIS score, wrinkle reduction, skin elasticity, and barrier function, as well as high participant's satisfaction, with no adverse events reported. These outcomes indicate that long-pulsed Nd: YAG 1064nm laser combining with a relatively lower concentration of 15% glycolic acid could be offering a safe and effective multimodal approach for clinical facial rejuvenation.

5.2 Conclusion

The combination treatment of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid is effective, safe, and well tolerated for facial rejuvenation in Fitzpatrick skin types III–V. It significantly reduces wrinkles, improves skin elasticity, enhances barrier function, and yields high participant's satisfaction without adverse events. This combined treatment provides a non-ablative and non-invasive option for patients seeking safe and effective facial rejuvenation with minimal downtime. Moreover, the findings of this study may serve as a valuable reference for guiding future clinical applications and research in facial rejuvenation treatments.

5.3 Limitations

While the findings of this study are encouraging, several limitations should be noted. The study population included only Fitzpatrick skin types III-V, which restricts applicability to other skin types, and no histological confirmation of collagen or elastin changes was performed due to cosmetic concerns.

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APPENDIX A

DOCTOR'S RECORD FORM

Volunteer number:

Effects of combination treatment of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid for facial rejuvenation

Table A1 Wrinkle Score

	Wrinkle score			Mean
	Front	Right	Left	
Baseline				
4 th week				
8 th week				
12 th week				

Table A2 Skin Elasticity Score

	Skin Elasticity Score				Mean
	Right Cheek	Right Forehead	Left Cheek	Left Forehead	
Baseline					
4 th week					
8 th week					
12 th week					

Table A3 Trans-epidermal Water Loss Score

	Trans-epidermal Water Loss Score				Mean
	Right Cheek	Right Forehead	Left Cheek	Left Forehead	
Baseline					
4 th week					
8 th week					
12 th week					

Table A4 Global Aesthetic Improvement Scale

	Degree	Description
5	Marked improvement	optimal aesthetic outcome achieved
4	Notable improvement	Significant improvement in appearance, though not fully optimal
3	Mild improvement	Moderate improvement compared with baseline; additional intervention recommended
2	Unchanged	Minimal or no change relative to baseline
1	Clinical worsening	Deterioration relative to baseline

GAIS	1 st Dermatologist	2 nd Dermatologist	3 rd Dermatologist	Mean
4 th week				
8 th week				
12 th week				

Table A5 Adverse Events at Baseline, 4th week, 8th week, and 12th week

Follow up	Baseline			
Symptoms	Yes	No	Duration	Remark
Pain				
Swollen				
Redness				
Bruise				
Hyperpigmentation				
Others				
Follow up	4 th week			
Symptoms	Yes	No	Duration	Remark
Pain				
Swollen				
Redness				
Bruise				

Table A5 (continued)

Follow up		4th week		
Symptoms	Yes	No	Duration	Remark
Hyperpigmentation				
Others				
Follow up		8th week		
Symptoms	Yes	No	Duration	Remark
Pain				
Swollen				
Redness				
Bruise				
Hyperpigmentation				
Others				
Follow up		12th week		
Symptoms	Yes	No	Duration	Remark
Pain				
Swollen				
Redness				
Bruise				
Hyperpigmentation				
Others				

APPENDIX B

RESEARCH PROFILE (CONFIDENTIAL)

การวิจัย (ข้อมูลลับ)

Volunteer Number:

General Information (ข้อมูลทั่วไป)

1. DOB (วันเกิด):
2. Gender (เพศ)
 - o Male (ชาย)
 - o Female (หญิง); please answer following question (กรุณาตอบคำถามต่อไปนี้):
 - i. Pregnancy or Lactation (การตั้งครรภ์หรือการให้นมบุตร)
 - o Yes (ใช่)
 - o No (ไม่)
3. Underlying disease (โรคประจำตัว):
.....
4. Photosensitivity or drug induced photosensitivity (ความไวแสงหรือความไวแสงที่เกิดจากยา):
 - o Yes (ใช่)
 - o No (ไม่)
5. History of food or drugs allergy (ประวัติอาการแพ้อาหารหรือยา):
.....
6. Facial skin conditions (สภาพผิวหนังใบหน้า):
 - o Scar or ulcers (แผลเป็นหรือแผลก่อดำ):
 - o Active dermatological condition (ภาวะโรคผิวหนังที่กำลังกำเริบ):
 - o Others (อื่น ๆ) (specify, โปรดระบุ):
7. Medical history (ประวัติทางการแพทย์):
.....
8. Current skin care products use (การใช้ผลิตภัณฑ์ดูแลผิวในปัจจุบัน):
.....

9. History of following procedures before the study (ประวัติการทำกระบวนการดังต่อไปนี้ก่อนการศึกษา):

- Chemical peeling (การลอกผิวด้วยสารเคมี)
- Dermabrasion (การขัดผิว)
- Any energy-based device or laser treatment (อุปกรณ์ที่ใช้พลังงานหรือการรักษาด้วยเลเซอร์)
- Neurotoxin treatment (การรักษาด้วยสารพิษทางประสาท)
- Collagen/fat injection (การฉีดคอลลาเจน / ไขมัน)
- Oral or topical retinoid (เรตินอยด์ชนิดรับประทานหรือทา)
- Other(อื่นๆ) (specify, โปรดระบุ):

10. Gynecology history (ประวัติทางนรีเวช) (if female):

- Pregnancy (การตั้งครรภ์)
- Breastfeeding (การให้นมบุตร)
- Willing to get pregnant during the study period (ยินดีที่จะตั้งครรภ์ระหว่างระยะเวลาในการศึกษา)

11. Personal History (ประวัติส่วนตัว):

- Alcohol (ดื่มเหล้า)
- Smoking (การสูบบุหรี่)
- Drug abuse (การเสพยาเสพติด)

12. Average sun exposure during 10 am to 5 pm (การได้รับแสงแดดเฉลี่ยระหว่างเวลา 10.00 น. ถึง 17.00 น.): minutes (นาที)/ hours (ชั่วโมง)

13. Fitzpatrick skin photo type (ประเภทผิวตามแบบจำลองฟิตซ์แพทริก):

- I
- II
- III
- IV
- V
- VI

APPENDIX C

CLINICAL EVALUATION

Table C1 Mean Wrinkle Score from VISIA® Complexion Analysis System at Baseline, 4th week, 8th week, and 12th week

Subject no.	Baseline	4 th week	8 th week	12 th week
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Table C2 Skin elasticity score from Cutometer® MPA 580 at baseline, 4th week, 8th week, and 12th week

Subject no.	Baseline	4 th week	8 th week	12 th week
1				
2				
3				
4				
5				
6				

Table C2 (continued)

Subject no.	Baseline	4 th week	8 th week	12 th week
7				
8				
9				
10				
11				
12				
13				
14				
15				

Table C3 Trans-epidermal water loss score from Tewameter® TM 300 at baseline, 4th week, 8th week, and 12th week

Subject no.	Baseline	4 th week	8 th week	12 th week
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Table C4 The Mean GAIS score at 4th week, 8th week and 12th week

Subject no.	Baseline	4 th week	8 th week	12 th week
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Table C5 Participant's Satisfaction Score at 12th week

Subject no.	Participants Satisfaction Score
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Table C6 Adverse events record form at 4th week, 8th week, and 12th week

Subject no.	Follow up (week)	Pain	Swollen	Redness	Bruise	Hyper-pigmentation	Others
1	4 th						
	8 th						
	12 th						
2	4 th						
	8 th						
	12 th						
3	4 th						
	8 th						
	12 th						
4	4 th						
	8 th						
	12 th						
5	4 th						
	8 th						
	12 th						
6	4 th						
	8 th						
	12 th						
7	4 th						
	8 th						
	12 th						
8	4 th						
	8 th						
	12 th						
9	4 th						
	8 th						
	12 th						
10	4 th						
	8 th						
	12 th						

Table C6 (continued)

Subject no.	Follow up (week)	Pain	Swollen	Redness	Bruise	Hyper-pigmentation	Others
11	4 th						
	8 th						
	12 th						
12	4 th						
	8 th						
	12 th						
13	4 th						
	8 th						
	12 th						
14	4 th						
	8 th						
	12 th						
15	4 th						
	8 th						
	12 th						

APPENDIX D

INFORMED CONSENT FORM

หนังสือแสดงความยินยอมเข้าร่วมการวิจัย

ข้าพเจ้า _____ ตัดสินใจเข้าร่วมการวิจัยเรื่อง
ประสิทธิภาพของการฟื้นฟูผิวหน้า ด้วยเลเซอร์ลองเฟาส์ เอ็นดี: แยก ความยาวคลื่น 1064 นาโนเมตร
ร่วมกับกรดไกลโคลิค 15% ซึ่งข้าพเจ้าได้รับข้อมูลและคำอธิบายเกี่ยวกับการวิจัยนี้แล้ว และได้มี
โอกาสซักถามและได้รับคำตอบเป็นที่พอใจแล้ว ข้าพเจ้ามีเวลาเพียงพอในการอ่านและทำความเข้าใจ
ข้อมูลในเอกสารให้ข้อมูลสำหรับผู้เข้าร่วมการวิจัยอย่างถี่ถ้วน และได้รับเวลาเพียงพอในการตัดสินใจ
ว่าจะเข้าร่วมการวิจัยนี้

ข้าพเจ้ารับทราบว่าข้าพเจ้าสามารถปฏิเสธการเข้าร่วมการวิจัยนี้ได้โดยอิสระ และระหว่างการ
การเข้าร่วมการวิจัย ข้าพเจ้ายังสามารถถอนตัวออกจากการศึกษาได้ทุกเมื่อ โดยไม่ส่งผลกระทบต่อ
การรักษา หรือสิทธิที่ข้าพเจ้าพึงมี

โดยการลงนามนี้ ข้าพเจ้าไม่ได้สละสิทธิใด ๆ ที่ข้าพเจ้าพึงมีตามกฎหมาย และหลังจากลง
นามแล้ว ข้าพเจ้าจะได้รับเอกสารข้อมูลและขอความยินยอมไว้จำนวน 1 ชุด
ลายมือชื่อผู้เข้าร่วมการวิจัย _____ วัน-เดือน-ปี _____
()

(กรณีที่ไม่สามารถอ่านหนังสือได้แต่ผู้วิจัยได้อ่านข้อความในเอกสารข้อมูลและขอความยินยอม นี้ให้แก่ข้าพเจ้าฟังจนเข้าใจแล้ว ข้าพเจ้าจึงลงนามหรือพิมพ์ลายนิ้วมือของข้าพเจ้าในหนังสือนี้ด้วย ความเต็มใจ	
ลงนาม/พิมพ์ลายนิ้วมือผู้เข้าร่วมการวิจัย _____	วัน-เดือน-ปี _____ ()

ลายมือชื่อผู้ขอความยินยอม _____ วัน-เดือน-ปี _____
()

คำรับรองของพยานผู้ไม่มีส่วนได้เสียกับการวิจัย (กรณีที่ผู้เข้าร่วมการวิจัยอ่านหนังสือไม่ออกแต่ฟังเข้าใจ)

ข้าพเจ้าได้อยู่ร่วมในกระบวนการขอความยินยอมและยืนยันว่า ผู้ขอความยินยอมได้อ่าน/อธิบายเอกสารข้อมูลให้แก่ _____ ซึ่งผู้มีชื่อข้างต้นมีโอกาสซักถามข้อสงสัยต่าง ๆ และได้ให้ความยินยอมเข้าร่วมการวิจัยโดยอิสระ หลังจากได้รับทราบข้อมูลที่มีอยู่ตรงตามที่ปรากฏในเอกสารนี้แล้ว

ลายมือชื่อพยาน _____ วัน-เดือน-ปี _____
(_____)



Informed Consent Form

I, _____, have decided to participate in Effects of Combination Treatment of Long-pulsed Nd: YAG 1064nm Laser and 15% Glycolic Acid for Facial Rejuvenation. I have received information and explanations about this research, and I have had the opportunity to ask questions and receive satisfactory answers. I have had sufficient time to read and understand the information provided in the documents thoroughly and have decided to participate in this research. I understand that I have the freedom to choose not to participate in this research, and I can withdraw from this research at any time without any impact on my care or rights that I am entitled to.

By signing this document, I do not waive any rights that I am entitled to under the law, and after signing, I will receive a copy of the information sheet and the informed consent.

Participant's Signature _____ Date _____
(_____)

..... (For illiterate participants who can understand though listening)

I cannot read, but the researcher has read this information sheet and informed consent form to me, and I understand it well. Therefore, I voluntarily sign or place my fingerprint.

Participant's signature/fingerprint _____ Date _____
(_____)

Signature of the person requesting consent _____ Date _____
(_____)

Testimony of a witness who is not a stakeholder in the research (If the participant cannot read but can understand through listening)

I have been present during the consent request process and confirm that the person requesting consent has read / explained the information sheet to _____. The aforementioned person had the opportunity to _____.

ask questions and decided to participate voluntarily after understanding the information in this document.

Witness's signature _____ Date _____

(_____)



APPENDIX E

PARTICIPANTS' SATISFACTION FORM

แบบฟอร์มความพึงพอใจของผู้เข้าร่วม

Volunteer Number:

Please score the satisfactory scale according to your desire and satisfaction after 3 sessions of the combination treatment of long-pulsed Nd: YAG 1064nm laser and 15% glycolic acid for your facial rejuvenation. (กรุณาประเมินคะแนนความพึงพอใจตามความต้องการและความพึงพอใจของคุณหลังจากการรักษาครบ 3 ครั้ง ผิวหน้า ด้วยเลเซอร์ลองพัลส์ เอ็นดี: แยก ความยาวคลื่น 1064 นาโนเมตร ร่วมกับกรดไกลโกลิค 15% เพื่อการฟื้นฟูผิวหน้า)

(Please choose one of the following options/กรุณาเลือกหนึ่งในตัวเลือกต่อไปนี้)

- o Score 0 = Not satisfied (ไม่มีความพึงพอใจ)
- o Score 1 = Slightly satisfied (ความพึงพอใจเล็กน้อย)
- o Score 2 = Moderately satisfied (ความพึงพอใจปานกลาง)
- o Score 3 = Highly satisfied (ความพึงพอใจมากขึ้น)
- o Score 4 = Complete satisfaction (ความพึงพอใจมากที่สุด)

APPENDIX F

FIGURES OF CLINICAL EVALUATION

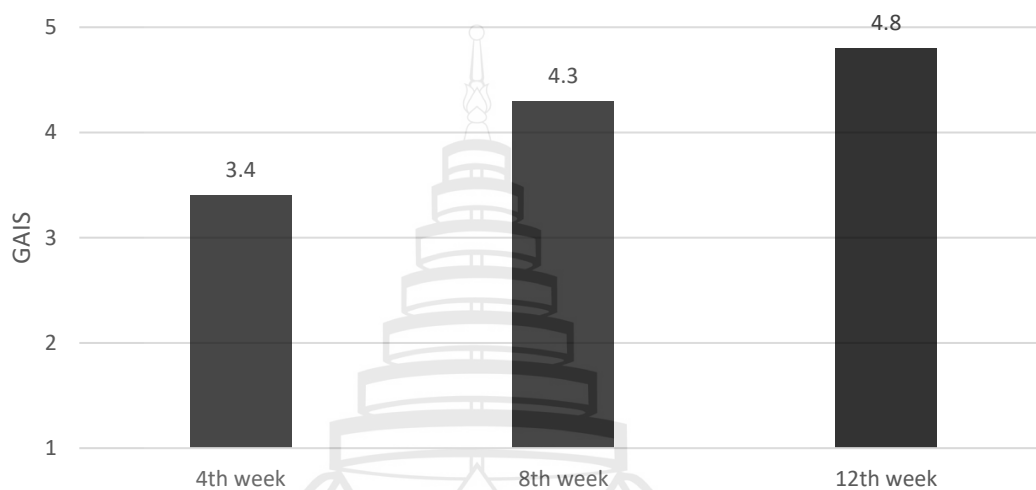


Figure F1 Bar chart depicting the progression of GAIS scores at weeks 4, 8, and 12

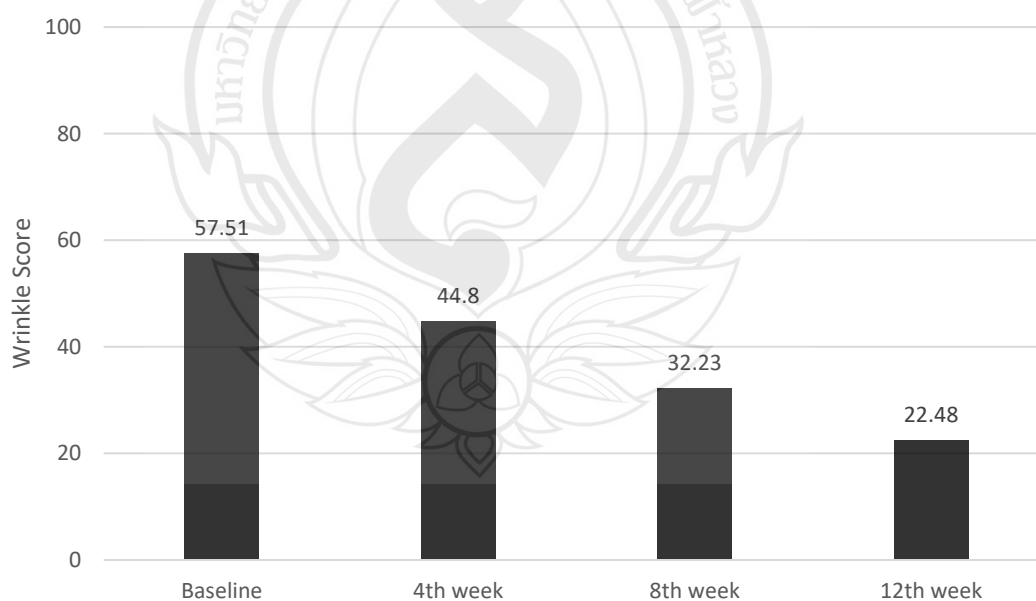


Figure F2 Bar chart depicting the progression of wrinkle scores at baseline, weeks 4, 8, and 12

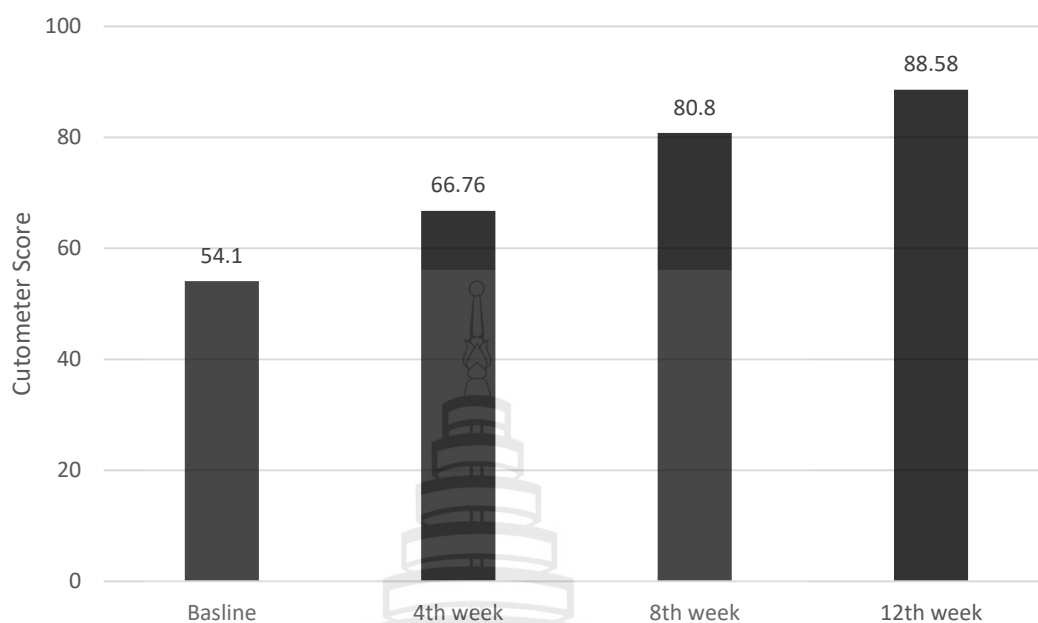


Figure F3 Bar chart depicting the progression of cutometer scores at baseline, weeks 4, 8, and 12

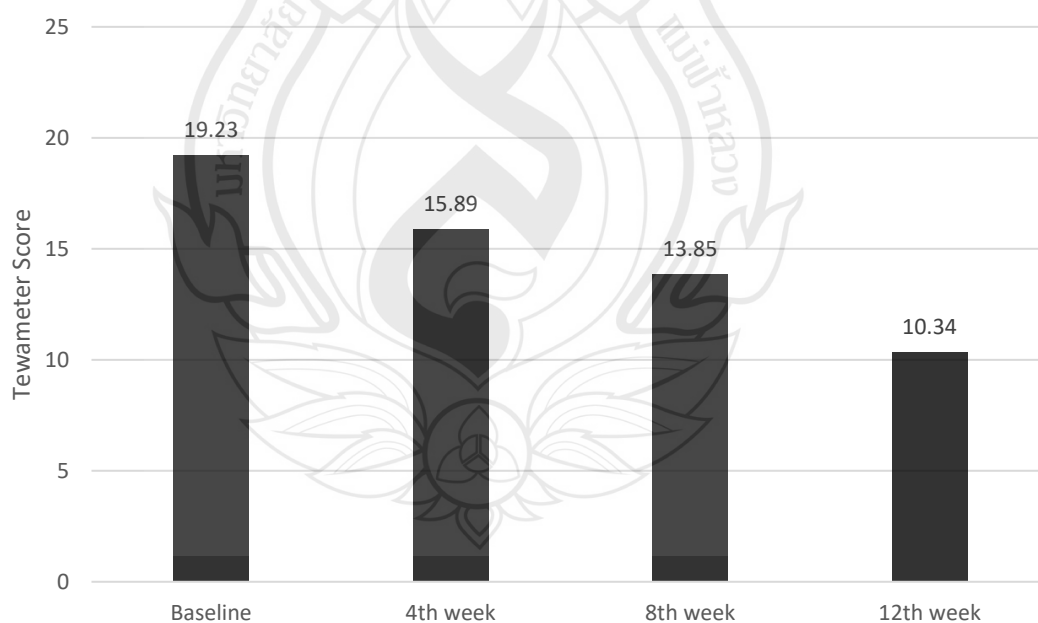


Figure F4 Bar chart depicting the progression of tewameter scores at baseline, weeks 4, 8, and 12

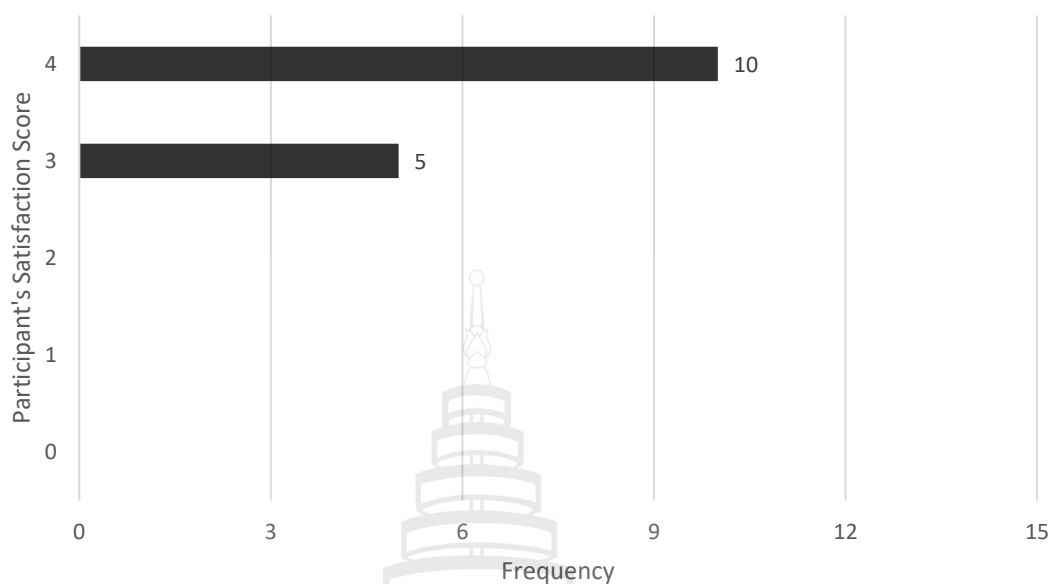
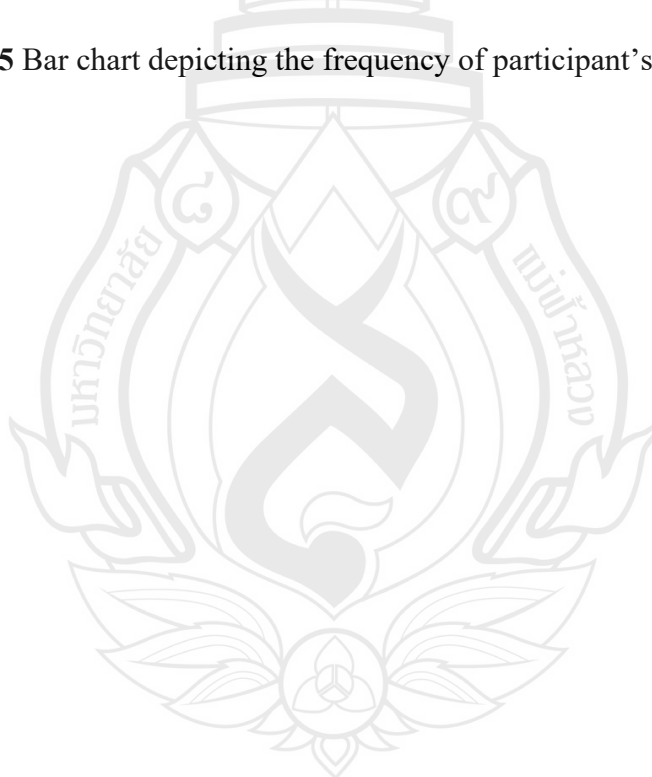


Figure F5 Bar chart depicting the frequency of participant's satisfaction score



CURRICULUM VITAE

NAME Sai Linn Linn

EDUCATIONAL BACKGROUND

2019 Bachelor of Medicine, Bachelor of Surgery (M.B., B.S)
University of Medicine, Mandalay, Myanmar

WORK EXPERIENCE

2019 House Officer
300 bedded Mandalay Teaching Hospital and
300 Bedded Children's Hospital

2021 Medical officer
MSC Liver Specialist Clinic

2022 Senior Medical Officer
Mingalar Myosett Private Hospital

