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A Nutrition & Cosmetology Approach, Boosting Collagen for Skin Anti-Aging.

[1]**Dr.Angelica Moses.** *BDS. DAVV University, Indore, INDIA.*

PGD-Clinical Cosmetology, Medical Trichology, Skin Aesthetic Laser. IICTN, Mumbai INDIA.

[2]**Dt.Apeksha Pragya Singh.** *B.Sc (Biotechnology), M.Sc (Food & Nutrition). DAVV University, Indore, INDIA.*

PGD-Food Safety Quality Management. IGNOU, INDIA.

Abstract: - Slowing the aging process by use of collagen has become a driving force in the field of dermatology, cosmetology & nutrition. Generally, oral (collagen rich foods) and topical (procedures & techniques) collagen is also used in anti-aging products. In the present scenario collagen has become the talk of the town due to its anti-aging miraculous effects on skin. This review is a modern take, evaluating & updating the present knowledge exploring new dimension trends & techniques in aesthetic industry for achieving anti-aged youthful skin through invasive, minimally invasive, non-invasive procedures & nutrition for boosting collagen.

Index Term: - Skin Aging, Nutrition, Collagen, invasive, minimally invasive & non-invasive cosmetology procedures.

I. INTRODUCTION

As the skin structure is made up of an intricate network which serves as the body's initial barrier and first line of defense combat against pathogens, UV light, Chemical damage & mechanical injuries besides this maintain thermoregulation, provides sensory & immune functions, provide lubrication and vitamin D synthesis. It not only protects the body from external environmental damage and avoids water loss from the body, but also has a certain cosmetic effect. [1] Aging of organs occurs throughout our life. As an individual age skin also shows obvious signs of aging, recently with the rapid development of science and technology and improvement in human living standards, people pay more attention to skin aging and try to have a better understanding of it. Many people, especially women, spend a significant portion of their daily expenses on cosmetics and medicines for the treatment and prevention of skin aging.[2]

1.1 SKIN ARCHITECTURE

Skin being the largest organ in the body envelopes the entire external surface, comprise of three layers, the Epidermis, Dermis & hypodermis all three of which vary significantly in their anatomy & functions. [14] The epidermis is composed of keratinocytes (90–95% of skin cells), Langerhans cells (2%), melanocytes (3%), and Merkel cells (0.5%). The epidermis contains the stratum corneum, hyaline layer, granular layer, and germinal layer, from the shallowest to the deepest. The stratum corneum is the key to maintaining optimal skin hydration. Cells in the germinal layer continue to proliferate and migrate to the upper layer to supply the constantly shedding stratum corneum. The germinal layer contains melanocytes that can produce melanin and the content of melanin is one of the factors that determines skin color. The dermis is made up of connective tissue and also contains appendages including sweat glands, sebaceous glands, blood vessels, and nerves. The dermis is divided into the papillary layer and reticular layer, and there is no obvious boundary between the two layers. The thickness of the dermis is around 0.07–0.12 mm; the dermis of the palms and soles is thicker (~1.4 mm); the eyelids and tympanic membrane are thinner (~0.05 mm). The papillary layer is connected to the germinal layer of the epidermis, and the reticular layer is combined with the subcutaneous tissue. One of the main cell types in the dermis is fibroblasts, which play a vital role in skin aging. Fibroblasts synthesize and secrete ECM, including collagen, hyaluronic acid (HA), and elastin. Collagen is the most important ECM in the dermis of the skin. Loss of collagen will directly lead to skin sagging, aging, and decreased elasticity. HA is synthesized at the plasma membrane by HA synthases 1–3 and is known to play a key role in wound healing and tissue repair processes due to its ability to maintain a humid environment. In the dermal fibroblasts, HA synthase 2 seems to be the major isoform. Elastin is the main component of elastic fibers in matrix tissue and provides resilience and elasticity to tissues and organs. The reticular layer contains collagen fibers, elastic fibers, and reticular fibers, which interweave into a net to create elasticity and toughness in the skin. Existing evidence suggests that damage to macromolecules present in the dermal ECM is indeed associated with skin aging. The subcutaneous tissue is composed of loose connective tissue and fat lobules, and it connects the dermis with the fascia, aponeurosis, or periosteum. [13]

II. COLLAGEN

Collagen is an abundant structural protein in all animals. The name "COLLAGEN" is used as a generic term for protein forming a characteristic triple helix of three polypeptide chains & all members of the collagen family form supra-molecular structure in the extracellular matrix although their size, function & tissue distribution vary considerably. [15] In humans, collagen comprises one-third of the total protein, accounts for three-quarters of the dry weight of skin, and is the most prevalent component of the extracellular matrix (ECM). Twenty-eight different type of collagen composed of at least 46 distinct polypeptide chains have been identified in vertebrates, and many other proteins contain collagenous domains. The defining feature of collagen is an elegant structural motif in which three parallel polypeptide strands in a left-handed, polyproline II-type (PPII) helical conformation coil about each other with a one-residue stagger to form a right-handed triple helix. [4] Comprises of amino acid glycine (33%), proline and hydroxyproline (22%) (primary structure) in a triplex helix which is formed by three α chains. Each alpha chain is composed for 1014 amino acids approximately with a molecular weight around 100 kDa. These chains are coiled into a left-handed helix with three amino acids per turn (secondary structure). The chains are twisted around each other into a triple helix to form a rigid structure (tertiary structure). The super helix represents the basic collagen structure (quaternary structure). This collagen structure is very stable because of the intramolecular hydrogen bonds between glycine in adjacent chains. [23] In animals, individual collagen triple helices, known as tropocollagen (TC), assemble in a complex, hierarchical manner that ultimately leads to the macroscopic fibers and networks observed in tissue, bone, and basement membranes. [4] The concentration of collagen varies in different tissues of the body. About 23% collagen is contained in the cranial bones, 50% – in the cartilage, 64% – in the cornea of the eye, and 74% – in the skin.

2.1. TYPE OF COLLAGEN

(TABLE: - 1) TYPES & TISSUE DESTRIBUTION OF COLLAGEN IN HUMAN BODY.

	TYPE	MOLECULAR FORMULA	POLYMERIZED FORM	TISSUE DESTRIBUTION
FIBRIL-FORMING. (fibrillar)	I	$[a1(I)_2a2(I)$	Fibril	Bone, skin, tendons, ligaments, cornea
	II	$[a1(II)]_3$	Fibril	Cartilage, inter-vertebrate disc, notochord, vitreous humor in the eye
	III	$[a1(III)]_3$	Fibril	Skin, blood vessels
	V	$[a1(V)]_2a2(V)$	Fibril (assemble with type I)	Idem as type I
	XI	a1(XI)a2(XI)a3(XI)	Fiber (assemble with type II)	Idem as type II
FIBRIL ASSOCIATED.	IX	a1(IX)a2(IX)a3(IX)	Lateral association with type II fibril	Cartilage
	XII	$[a1(XII)]_3$	Lateral association with type I fibril	Tendons, ligaments
NETWORK FORMING.	IV	$[a1(IV)]_2a2(IV)$	Sheet-like network	Basal lamina
	VII	$[a1(VII)]_3$	Anchoring fibrils	Beneath stratified squamous epithelia

Note: - More than 90% of the collagen in the human body is a type of fibrillar collagen – Type I

2.2. COLLAGEN BIOSYSTHESIS

Collagen synthesis begins specialized cells called fibroblasts. It is here that amino acids undergo activation; Proline is hydroxylated to Hydroxyproline and Lysine to Hydroxylysine. Peptide subunits of ~250 residues are assembled on the ribosome and are linked by carbohydrate residues to form α-chains. Three α-chains then associate with each other and then further associate extra-cellularly forming a molecule with a molecular weight of 360,000. Bonds are further strengthened thus forming the insoluble collagen fibril. During the process of collagen synthesis, free-hydroxyproline and hydroxylysine peptides appear as by-products, some of which are metabolized and may appear in urine [5]. The molecular mass of collagen is about 300 – 400kDa. In collagen peptides which are small peptides with molecular weight is up to 5000Da. [3]

2.3. COLLAGEN RELATED DISORDERS

- Osteogenesis imperfecta - Caused by a mutation in type 1 collagen, as it is a dominant autosomal disorder it results in weak bones & irregular connective tissues, some cases can be mild while others can be lethal, mild cases having lowered levels of collagen type 1 while severe cases have structural defects in collagen.
- Ehlers-Danlos Syndrome - Disorder leading to deformities in connective tissue. Some types can be lethal which can lead to the rupture of arteries.
- Alport syndrome - A genetical disorder, can be inherited usually as X-linked dominant, but also as both an autosomal dominant and autosomal recessive disorder, sufferers have problems with their kidneys & eyes, loss of hearing can also develop during childhood or adolescent years.
- Osteoporosis - Not inherited genetically but brought on with age, associated with reduced levels of collagen in the skin & bones, growth hormone injections are being researched as a possible treatment to counteract loss of collagen.
- Knobloch syndrome - Caused by a mutation in the collagen XVIII gene patients present with protrusion of the brain tissue & degeneration of the retina, an individual who has family members who suffer the disorder are at an increased risk of developing it themselves as there is a hereditary link.
- Stickler Syndrome - A genetic condition causing vision hearing & joint disorders.
- Epidermolysis Bullosa - A inherited blistering disorder caused by mutations in the COL7A1 gene encoding type VII collagen. [8]
- Marfan Syndrome - A connective tissue disorder, C caused by the defect in the gene that encodes the structure of fibrin & elastic fibers.
- Systemic Lupus Erythematous - It is one of the most severe form of auto-allergic disease. It may develop spontaneously or as a result of transformation from chronic forms due to irrational treatment, ultraviolet irradiation, stress.
- Systemic Sclerosis - Collagen type V is a highly immunogenic extracellular matrix protein with preserved globular and telopeptide domains found inside heterotypic fibrils mixed with collagen types I and III. In humans, it is detected in many tissues including skin, lungs, gastrointestinal tract, cornea, liver, spleen and vessels basement membrane. [9]

- Oral Submucous Fibrosis - OSMF is a precancerous condition in which there is excessive deposition of collagen in connective tissue, subsequent to which there are changes in epithelium. [10]
- Vitamin A Deficiency - Retinoid signaling participates in the expression of ECM proteins including collagen, laminin, entactin, fibronectin, elastin and proteoglycans. In addition, RA also affects the expression of cell membrane ECM receptors. Consequently, vitamin A deficiency can induce changes in the composition and structure of ECM to result in alterations of organ function and pathological consequence, which could be reversed by appropriate treatment with retinoids. [11]
- Vitamin C Deficiency - Scurvy is caused by ascorbic acid's role in collagen synthesis. Collagen type IV is the main constituent of blood vessel walls, skin, and specifically, the basement membrane zone separating the epidermis from the dermis. Vitamin C allows hydroxylation and crosslinking of pro-collagen catalyzed by lysyl hydroxylase. Lack of vitamin C decreases transcription of pro-collagen. Additionally, a lack of ascorbic acid leads to epigenetic DNA hypermethylation and inhibits the transcription of various types of collagen found in skin, blood vessels, and tissue. [12]

III. CHANGES AND MOLECULAR MECHANISM IN SKIN AGING

- **Oxidative stress-** Oxidative stress plays an important role in skin aging and skin damage processes, and its main feature is increased intracellular ROS. The skin's oxidative metabolism and UV exposure lead to the production of ROS. The accumulation of ROS causes DNA damage, induces skin inflammatory response, reduces antioxidant enzymes, activates nuclear factor kappa B (NF-kB) and activator protein1 (AP–1) to inhibit collagen production, and increases matrix metalloproteinases to decompose collagen and binding proteins in the dermis, which eventually leads to skin aging.
- **DNA damage and gene mutation-** Earlier studies reviewed the mechanisms of UV-induced DNA damage and classified them into direct damage and indirect damage. Direct damage occurs when DNA absorbs the UV-B photon, leading to rearrangement in the nucleotide sequence, resulting in DNA strand deletion or mutation. During indirect damage, DNA molecules absorb UV-A and promote electron and energy transfer to oxygen molecules to form free radicals' singlet oxygen ions, causing DNA damage. DNA damage can be repaired by photolytic enzymes, while UV-induced skin DNA damage can be prevented by applying sunscreen.
- **Shortening of the telomere-** Telomeres are a small piece of DNA-protein complex at the end tips of eukaryotic linear chromosomes, which are important components in maintaining the chromosomal integrity and controlling the cell cycle. A telomere is shortened with cell division and is associated closely with cell division and senescence. Telomerase is an enzyme responsible for telomere elongation, and its synthesis is essential for telomere maintenance and long-term survival of the organism. Epithelial stem cells with short telomeres have a poor proliferative capacity, which can be corrected by introducing telomerase. The reactive oxygen generated by UV radiation induces telomere mutation, cell death, or senescence.
- **The role of microRNA-** miRNAs are a type of conserved non-coding RNA. Chronic UV-B alters the expression of mir–34 family proteins in the skin. MiR–34 in human dermal fibroblast (HDFs) cells regulates cell function and expression of MMP–1, α1 type1 collagen (COL1A1), and elastin. miRNA 378b inhibits mRNA expression of COL1A1 by interfering with Sirtuin 6 (SIRT6) in HDFs, miRNA 217 regulates the senescence of human skin fibroblast by directly targeting DNA methyltransferase 1, and miR–23a–3p controls cellular senescence by targeting enzymes to control hyaluronic acid synthesis. These studies thus show that microRNAs regulate the skin aging process.
- **Accumulation of advanced glycation end products (AGEs)-** AGEs are the products of excess sugar and protein binding, usually derived from body synthesis and food intake. The nonenzymatic glycosylation aging theory has been widely recognized by many scholars. As the final product of nonenzymatic glycosylation reaction, AGEs accumulate in photo-aging skin, affect protein function in the dermis, and promote skin aging.
- **Aging due to inflammation-** Continuous UV radiation exposure induces oxidative stress in epidermal cells, causing cell damage, fat oxidation, and finally leads to cell inflammation. When the degree of inflammation exceeds the ability of macrophages to clear up, macrophages also begin secreting pro-inflammatory factors and ROS to accelerate dermal inflammation & injury. [13]

3.1. APPARENT CHANGES ON AGING SKIN

Aging is characterized by the accumulation of macromolecular damages, impaired tissue renewal, and progressive loss of physiological integrity. One of the hallmarks of aging is cellular senescence that is triggered by several intrinsic and extrinsic factors (listed above) leading to growth arrest and specific phenotypic alterations, such as chromatin and secretome changes. Cellular senescence prevents the uncontrolled proliferation of damaged cells and induces the clearance and the regeneration of the tissue. However, in old organisms, the accumulation of several damages and the deficiency of immunological surveillance result in senescent cell accumulation and impaired tissue homeostasis. [16] Skin aging can be distinguished in intrinsic or chronological aging and extrinsic or photo-aging, which are superimposed in the sun-exposed area of the body. [17]

(TABLE: -2) COMPARISON OF INTRINSIC AGING & PHOTO-AGING (clary et.al, 2014; Mukherjee et al, 2006)

FEATURE	INTRENSIC AGING	PHOTO AGING
CLINICAL APPERANCE	Fine wrinkles, some deepening of skin surface markings, some loss of elasticity, redundant skin, skin is smooth, unblemished, but show saggy appearance.	Nodular, leathery surface sallow complexion, yellowish mottled pigmentation, coarse wrinkles, severe loss of elasticity, reddened appearance with initially light wrinkles, which later deepen, thus showing loss of collagen fibers.
EPIDEMIS	Thin & viable: thinner than normal with lower cell growth, minor abnormalities in keratinocytes regularity; normal stratum corneum there is loss of rete pegs as well.	Marked acanthosis, cellular atypia; thick skin, with acanthosis followed by atrophy of the cell; high basal keratinocyte irregularity; stratum corneum appears compact; there is loss of rete pegs as well.
ELASTIC TISSUE	Increased, but almost normal.	Tremendous increase, degenerates into amorphous mass.
RETICULAR DERMIS	Thinner, fibroblast decreased, interactive mast cells decrease, no inflammation, elastic fibers appear	Thickened, elastosis, fibroblast increased, hyperactive mast cell; excessive production of elastin fibers in an

	irregular in their arrangement, whereas collagen fibers begin to lower in number & thickness.	improper orientation, collagen fibers appear to thicken & then wear out soon; appearance of grenz zone.
COLLAGEN	Bundles thick, disoriented.	Marked decrease of bundles & fibers.
GLYCOSAMINOGLYCANS	Slightly decreased.	Markedly increase.
PAPILLARY DERMIS	No grenz zone.	Solar elastosis.
MICROVASCULAR	Moderate loss.	Great loss, abnormal & telangiectatic.

3.2. BENEFICIAL ANTI-AGING EFFECTS OF COLLAGEN ON SKIN

- Improves skin, facilitate antiaging effects.
- Prevents bone loss.
- Increase muscle mass.
- Improves joints.
- Maintaining a healthy gut.
- Maintaining a healthy weight.
- Reducing anxiety.
- Improving mood.
- Promoting healthy nail and hair growth.

AFTER *BEFORE* *BEFORE* *AFTER*

INTRENSIC AGING. **PHOTO AGING.**

3.3. OTHER USES OF COLLAGEN

Periodontitis - Periodontitis is a highly prevalent disease among adults that is usually triggered by a bacterial infection and it affects the tissues surrounding the dentition. If left untreated, it can lead to loss of teeth. The use of a membrane is expected to promote wound stabilization and defend the adhering clot from tensile forces onto the external portion of the membrane. This barrier allows the body to regenerate periodontal ligament, cementum, and bone. Thus, RCMs could be successfully utilized in clinics to treat localized periodontitis and increasing patient comfort. [25]

3.4. SIDE-EFFECTS OF COLLAGEN

- Increased risk of development of kidney stone.
- Drinking collagen daily can rise calcium levels the side effect occurs as many collagen products contain high levels of collagen from marine sources giving rise to fatigue, constipation, nausea, vomiting & bone pain.
- Allergic reaction could be induced due to high levels of collagen, which could in rare cases be life threatening symptoms to an allergic reaction include itching or tingling in the mouth or area of skin where collagen is applied, swelling of tongue, skin wheezing.
- One of the worst effects of collagen supplementation is that it can mess with the mood or mental status. Adding extra collagen protein to the regimen could lead to a deficit in tryptophan. A decrease in tryptophan will cause serotonin levels to lower which will bulldoze into possibly gaining feelings of nervousness, irritability, anxiety, and depression. This is especially important to note if patient is already suffering from a mood disorder.

IV. DIET MANAGEMENT FOR SKIN AGING

Food is the foundation of our lives, and diet is the main way for the body to obtain the required substances for growth and maintenance hence diet and nutrition are two sides of the same coin. Human beings group themselves into different ethnicity, religions, nationalities, and catering cultures having a powerful and complex impact on the individual. More than 2000 years ago, the Chinese medical book "Yellow Emperors Internal Classic. Su Wen" contained a balanced diet principle of "five grains for nutrition, five fruits for help, five animals for benefit, and five vegetables for filling", and the folk also includes "what to eat and what to add". Modern science has proven that an imbalance in nutrition and poor eating habits are important causes of skin aging. Aging has a detrimental effect on connective tissue in the skin, leading to declines in elastin and collagen fibers and thus resulting in fine lines and wrinkles. [19] Addition of omega-3 oil from flex seed & omega-6 rich oil from the borage plant leads to decrease in skin roughness & scaling. There is a large demand for collagen in the food industry because it has high protein content and good functional properties such as water absorption capacity and the ability to form emulsion. [24] Vitamin C is proven to be a needed nutrient in helping the body to create its own collagen. Most of the collagen supplements recommended by experts are enriched with peptides containing amino acids - including proline, glycine, and hydroxyproline - considered to be essential components of collagen. [20]

4.1. DIETARY SOURCES OF COLLAGEN

Collagen diet is an eating habit or plan to facilitate consumption of food's high in collagen that helps or improves the skin and beauty of an individual. As collagen is the key component of structural protein found in skin & connective tissues providing strength & elasticity, endogenous collagen is synthesized within the body while exogenous collagen has to be acquired by dietary sources

or supplements, as exogenous collagen is widely used for cosmetic purposes for healthy youthful and to maintain optimal skin health substances high in collagen or required for the synthesis of collagen like antioxidants & vitamins must be consumed. "We are what we eat" (by-Alice Waters), Explains the importance of organic self-grown food to preserve its nutritional value & to restrict of fast-food culture.[21] Study conducted by Vinien W.Fam & Raja K. Sivamani on plant-based foods for skin health provide evidence of the potential benefits of plant-based foods for skin health & esthetics, Many of the foods and extracts discussed rich in bioactive compounds such as Vit C, alpha tocopherol, beta carotene, polyphenols, and phenolic acids that provide oxidant defense, support mechanisms to lower inflammation, or promote structural support and UV protection in the skin. [40]

(TABLE: - 3) COLLAGEN BOOSTING FOODS.

COLLAGEN BOOSTING FOODS	ADDITIONAL NUTRITIONAL CONTENTS	BENIFICIAL EFFECTS	LOCATION & HIGH CONSUMPTION
BERRIES	Vitamin C, iron, phosphorous, calcium, magnesium, manganese, zinc, and vitamin K	Vitamin C is a strong antioxidant found in berries. Eating vitamin C–rich berries will contribute to radiant skin and healthy hair, and may reduce the risk of arthritis, cataracts, and macular degeneration. Some people with IBS experience discomfort after eating berries. [26]	In India- Andhra Pradesh World- Australia, New Zealand and South American nations.
FLAXSEED	Fibers, lipids, protein	Supplementation with flaxseed oil led to significant decreases in sensitivity, skin roughness and scaling, while smoothness and hydration were increased. [27]	In India- M.P, U.P, Bihar, Assam. World – North Europe & Russia.
FISH	Omega-3, Omega-6, protein	Fish skin typically contains type I collagen with a high degree of purity (around 70%) depending on the species age and season. Collagen from fish skin demonstrates an excellent capacity to retain water (about 6% of its weight in exposure to 63% humidity for 24 h). [28]	In India- Kerala, west Bengal. World – China.
RED BELL PEPPERS	Vitamin A, C, potassium, fibers, folate & Iron.	Vitamin C is important for many functions in the body, including: producing collagen in the body, which is essential for healing wounds and forming connective tissue. [34]	In India- Karnataka. World- China, Mexico, Indonesia.
TOMATO	Protein, Lipid, carbohydrates, sugar, vitamin C, folate, potassium	Golden tomato extract may provide benefits to the skin by enhancing innate immunity and other defense mechanisms in the dermis and by providing anti-oxidants to the skin surface to optimize TEWL and the appearance of the skin. [32]	In India- Gujrat, Maharashtra, Chhattisgarh World- China, India, Pakistan, Turkey
BONE BROTH	Protein, fat, carbohydrate, fiber.	Hide is a by-product of meat production and is mostly used for leather production. Waste bovine hide off-cuttings can be used to extract high value product of collagen. AES2 proved to be the most preferable method of extraction out of the three methods applied and considering leather to collagen revenue, waste bovine hide off-cuttings could potentially result in substantial revenue. [33]	World- North America, China.
POMEGRANATE	Vitamin C, potassium, fibers	Pomegranate peel extract (and to a lesser extent, both the fermented juice and seed cake extracts) stimulated type I procollagen synthesis and inhibited matrix metalloproteinase-1 (MMP-1; interstitial collagenase) production by dermal fibroblasts. [31]	In India- Maharashtra World- Afghanistan.
EGG	High quality protein, fat, iron, protein, vitamin E	The bio-mechanical, hydrating and barrier properties of the skin after regular eight-week topical application of the gel formulation with the addition of chicken collagen hydrolysate it is obvious that chicken collagen hydrolysate is an effective cosmetic ingredient comparable to bovine and porcine collagen peptides and hydrolysates. [35]	In India- Telangana, Tamin Nadu World- Mexico, Japan, China, Ukraine, Malaysia
DARK LEAFY GREENS	High level of fibers, iron, magnesium, potassium, calcium	Consuming not enough fruits, vegetables are associated with ill skin health. Fruits and vegetables are foods for healthy skin and because they contain high amounts of antioxidants can help to protect skin from early skin – ageing appearance. The fruits and vegetables juices improve blood vessels flow which enhance skin aesthetic.[30]	In India- Uttar Pradesh, Bihar, Madhya Pradesh World- China
CHICKEN	Vitamin B12, zinc, iron, choline	As per the study conducted by the Laval University food science & nutrition department on Extraction & characterization of collagen with or without telopeptides from chicken skin The total collagen content of the skin was recovered from the solid phase following heat treatment at40°C. Extraction yields varied with the solubilization process: 38.9% of the collagen content in the solid phase was extracted with pepsin and 25.1% with ethylene diamine. Ratios of type I to type III collagen fractionated using NaCl were 74.4:19.8% with pepsin and 62.4:31.7% with ethylene diamine. Characterization tests further revealed the presence of telopeptides solely on ethylene diamine-solubilized collagen. Chicken skin thus appears to be a good alternative source of high-quality collagen. [37]	In India- Tamil Nadu, Andhra Pradesh World- United States, China

LEGUMES	Vitamin C, B6, iron, magnesium, calcium, potassium, sodium, protein, fiber	Consumption of select fruits and vegetables rich in vitamins and polyphenols, nuts and legumes abundant in mono- and poly-unsaturated fats, as well as polyphenolic-rich beverages, can improve skin health. Beneficial skin effects vary but include an improvement in hydration, hyperpigmentation, wrinkles, erythema, collagen, and elasticity. [40]	In India- Rajasthan, Madhya Pradesh World- China, India, United States
OYSTERS	Zinc, selenium, vitamin B12, copper, iron, manganese, vitamin, riboflavin, calcium	The use of oyster powder for preparing collagen, elastin and keratin for fair skin, hair and nails. [36]	In India- Cochin World- China, South Korea
NUTS	Sodium, potassium, dietary fibers, protein, iron, vitamin B6, magnesium, calcium.	Nuts contents essential fats or fatty acids, vitamin E and B vitamins which retain skin elasticity and quality toward glowing skin. Sunflower seeds for example are a great source of vitamin E which promote skin health. [29]	In India- Maharashtra, Andhra Pradesh. World- United states, China.
AVOCADO	Sodium, potassium, protein, vitamin C, fats, iron vitamin B6, Calcium, magnesium	In a study conducted by the Department of Medicine Centre for Human Nutrition, Los Angeles USA, on Avocado consumption increased skin elasticity & firmness in women demonstrated Elasticity and firmness were increased at forehead comparing 8 weeks to baseline in the avocado group. Comparing avocado to control, change in firmness marker from baseline to week 8 indicated a significant increase in forehead skin firm-ness in the avocado group. [38]	World- Mexico, Peru, Indonesia, Colombia, Chile
GINSENG	Potassium, vitamin C, Sodium	Study conducted by the College of pharmacy, Seoul National University on Ginseng increases type I collagen stated that, SG increased type I collagen production directly and/or indirectly by reducing MMP-1 and stimulating TIMP-1 production in human dermal fibroblasts. SG dose-dependently induced fibroblast proliferation and this, in turn, can trigger more collagen production. These results suggest that SG may be a potential pharmacological agent with anti-aging properties in cultured human skin fibroblast. [39]	In India- Himachal Pradesh, Tripura, Uttarakhand, Maharashtra World- China, South Korea

4.2. FOODS TO BE AVOIDED FOR OVERALL SKIN HEALTH

- Sugar (promotes inflammation risk and rapid skin aging)
- Spicy hot food (promotes facial redness).
- Caffeine (possible dehydration, but also anti-inflammatory effect).
- Chocolate and fatty foods (sugar and saturated trans fats).
- Alcohol (excessive drinking - free radicals, diuretic)
- Processed foods (lack of micronutrients & excess of preservatives - emulators, colors, taste enhancers, aromas).
- Fatty and fast foods and hydrogenised oils (lack of vitamins and minerals, high level of preservatives).
- Salt (water retention, bloating).
- Starch (white flour products). [22]

V. COSMETOLOGY PROCEDURES BOOSTING COLLAGEN

Cosmetic procedures & preparations were used by people since they got aware about their looks (regardless of the gender). The US Federal Food, Drug and Cosmetic Act written in 1938, defined cosmetic as an "articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body or any part for cleansing, beautifying, promoting attractiveness, or altering the appearance", without affecting any structure or function of the body. [7] Collagen is chosen to be used in cosmetic industry due to its biodegradability, availability & biocompatibility. The common sources of collagen are bovine, porcine, human collagen & marine organisms such as fish scale & fish skin. [6] There are a number of treatments proven to boost collagen in the skin, and nearly all of them revolve around creating a controlled wound, to stimulate the healing process. With the increasing demand of patients for rejuvenation treatments and their intense desire to achieve aesthetic improvement with minimal risk and a quick recovery, several non-surgical rejuvenation technologies have been developed. A wide variety of high-tech devices are presented as effective, selective and safe therapeutic options,[42] hence In-office cosmetology procedures are designed to create microdamage in order to induce new collagen to lay down, thereby plumping and smoothing skin.

(TABLE: -4) COSMETOLOGY PROCEDURES & TECHNIQUES BOOSTING COLLAGEN.

CLASSIFICATION OF AESTHETIC PROCEDURES	AESTHETIC PROCEDURES & TECHNIQUES	EFFECTS OF ASETHETIC PROCEDURES	ADVANTAGES	DISADVANTAGES
NON-INVASIVE.	**GALVENIC TREATMENT**	Galvanic current activates the NLRP3 inflammasome and induces an inflammatory response that promotes a collagen-mediated regeneration of the tendon. [56]	Acne scare healing, reduction of fine lines, boosts elasticity, increases cell metabolism	Galvanic shock may be felt in some cases. Not recommended for patients with metal implants, pacemakers, braces.
	RADIOFREQUENCY	RF appears to be the most established and clinically proven, with the advantage of reaching the skin in its depth, due to the fact that even the hypodermis can be affected, therefore Dermatology uses RF in	Improves skin elasticity, boost collagen production, lift & tightens face &	May cause atrophic scars

		a non-ablative way, promoting increased elasticity of tissues rich in collagen. [42]	neck, melts body fat, lymphatic drainage, reduce cellulite	
	LED LIGHT THERAPY	LED can trigger skin collagen synthesis with concurrent re-duction in MMP. A significant increase in collagen production after LED treatment has been shown in various experiments, including fibroblasts cultures, third-degree burn animal models, and human blister fluids, and skin biopsies. [53]	Treats acne, reduce inflammation, promotes anti-aging effects	May cause tissue & cell damage in some cases leaves burns.
	CHEMICAL PEELS (Example: - AHA, BHA, TCA)	Superficial peels exert their actions by decreasing corneocyte adhesion and increasing dermal collagen. These peels are a good method for rejuvenating the epidermis and upper dermal layers of skin. [54]	Exfoliate the skin, visible brightness, promotes collagen production, reduce apparent surface line's & wrinkles	Mild skin irritation, itching, swelling, skin discoloration
	HIFU	HIFU could be a safe, effective, and noninvasive procedure that can be used to improve facial wrinkles and skin laxity in Asian skin. It is particularly effective for clinical improvement in the jawline, cheek, and perioral areas. [43]	No scar formation, no risk of tumor seeding, precise ablation.	Long term treatment, no histological diagnosis
	FARADIC TREATMENT	Faradic and dia-dynamic stimulation promoted the most significant response in both speed and directionality. Faradic stimulation has been shown to promote collagen organization while dia-dynamic stimulation promotes skin wound healing. [44]	Increases cellular regeneration, improves contour, increases blood & lymphatic flow	Can cause tingling sensation & discomfort to patient
	INFRA-REDLIGHT THERAPY	The red wavelength LED significantly enhanced the skin graft score in relation to the NIR group and increased transforming growth factor beta (TGF-β) protein expression and density of collagen fibers compared with the other experimental groups. [46]	Enhances blood circulation in the skin, promotes oxygen supply & healing	Inflammatory cells may get triggered causing skin damage
TOPICAL APPLICATION	**VITAMIN C SERUM**	Vit. C protects the skin from oxidative stress by sequentially donating electrons to neutralize the free radicals. The exposure of skin to UV light generates ROS. These radicals have a potential to start chain or cascade reactions that damage the cells. The harmful effects of ROS occur as direct chemical alterations of the cellular DNA, the cell membrane and the cellular proteins, including collagen. [48]	Protects against sun damage, lighten dark spots, smooth wrinkles, boost collagen, promotes healing	Tingling sensation upon application, skin irritation, redness, itching
	HYALURONIC ACID	HA based formulations (i.e., gels, creams, intra-dermal filler injections, dermal fillers, facial fillers, autologous fat gels, lotion, serum, and implants, etc.) exhibit remarkable anti-wrinkle, anti-nasolabial fold, anti-aging, space-filling, and face rejuvenating properties. This has been achieved via soft tissue augmentation, improved skin hydration, collagen and elastin stimulation, and face volume restoration. [52]	Facilitate soft tissue growth, promotes collagen & elastin production, moisturize skin, reduce scaring	May cause Pain, redness, itching, swelling, bruising
	VITAMIN E OIL	Topical vitamin E has emerged as a popular treatment for a number of skin disorders owing to its antioxidant properties. It has been seen that reactive oxygen species have the ability to alter the biosynthesis of collagen and glycosaminoglycans in skin. [49]	Moisturize skin, wound healing	May cause rashes, allergies, contact dermatitis, skin sensitivity
	VITAMIN A SERUM	Vitamin A and its derivatives are among the most effective substances slowing the aging process. Retinoids regulate the cell apoptosis, differentiation and proliferation. Anti-wrinkle properties of retinoids promote keratinocytes proliferation, strengthen the protective function of the epidermis, restrain trans-epidermal water loss, protect collagen against degradation	Potent antioxidant, prevents macular degradation	May cause skin irritation, peeling & erythema

		and inhibit metalloproteinases activity [51].		
MINIMALLY INVASIVE	**LASER PHOTO REJUVENATION** (Ex: CO2, Alexandrite, Erbium, Pulse Dye laser, Nd:YAG, IPL)	Different assessments have revealed the survival and activation of fibroblasts and new keratinocytes with an increase of collagen and elastin fibers in the dermis and the reduction of matrix metalloproteinases (MMPs) and heat shock proteins (HSPs) as a result of different low power laser therapies on skin. [41]	Accuracy, precision, minimum side effects	Expensive, time consuming, in some cases there may be skin burns
	MDA	Study by Bruce M. Freedman To analyze the onset and extent of the dermatologic changes associated with microdermabrasion. Ten volunteers, ages 31-62 years, underwent a series of six aluminum oxide microdermabrasion facial treatments 7-10 days apart. Skin biopsy specimens were obtained prior to the study, after three treatments, and after six treatments. Compared to the controls, the treated areas demonstrated the following histologic changes: thickening of the epidermis and dermis, flattening of the rete pegs, vascular ectasia and perivascular inflammation, and hyalinization of the papillary dermis with newly deposited collagen and elastic fibers. [45]	Treats un even skin tone & texture, photo aging, treats melasma & scars	Dull looking skin, mild tenderness, swelling & redness
	PRP	PRP increases dermal collagen levels not only by growth factors, but also by skin needling (the mesotherapy technique 'point by point'). PRP application could be considered as an effective (even a single application) and safety procedure for facial skin rejuvenation. [47]	High Adaptability, non-scaring procedure, effective	High cost, tissue harm
	MICRONEEDLING	Micro-needling is an effective modality of treatment, especially in patients with Fitzpatrick's IV and V skin types because it overcomes the side effects of scarring and hyperpigmentation resulting from other procedures in which the epidermis is compromised. It certainly promises to be a valuable technique with its numerous applications. [50]	Reduce the appearance of fine lines & wrinkles, reduces hyperpigmentation	Bleeding, bruising infection, peeling
INVASIVE	**FILLERS**	The use of filler and collagen stimulator for body rejuvenation is a recent good option when well indicated. In general, better results are reached in younger patients, who are able to induce new collagen synthesis, but it can also be used for older patients. [55]	Smooth out fine lines & wrinkles, minimal pain, can help restore collagen, little to no recovery time is required.	Expensive procedure, can cause bleeding, bruises, procedure is not permanent

VI. CONCLUSION

Natural aging is genetically determined while extrinsic aging can be prevented, by facilitating collagen production with nutrition & externally through application of cosmetology procedures & techniques can contribute in reducing or delaying skin aging. Future meta-analysis and clinical researches studies with large sample size & thorough follow-up measures would be required to comprehensively demonstrate elevation of collagen synthesis through nutritional and cosmetology procedures and its anti-aging effect on skin.

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