ORIGINAL RESEARCH PAPER

Clinical Research

"BOVINE COLLAGEN SUPPLEMENTATION - EFFECTS ON MUSCLE STRENGTH IN OSTEOARTHRITIS SYMPTOMS RELIEF – A POST HOC ANALYSIS"

KEY WORDS: Bovine Collagen, muscle strength, muscle mobility, skin improvement.

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ABSTRACT

Bovine collagen is a protein found in the connective tissue, bones, cartilage, and hides of cows. Remarkably, the collagen derived from cows closely resembles the collagen found in our own bodies. Collagen is advantageous for managing osteoarthritis symptoms.The aim of the study was to evaluate the safety, tolerability, and effectiveness of continuous Bovine Collagen use in patients aged 30 to 50 with mild to moderate Osteoarthritis (OA) symptoms over an 8-week period. The study assessed improvements in joint pain, stiffness, swelling, muscle strength, sleep quality, and overall skin, hair, and nail health, while comparing three different doses (2.5g, 5g and 10g) of the test treatment.In this clinical study, upper body muscle strength was measured through push-up and plank exercises, revealing a significant increase in the number of push-ups in 60 seconds to >100%, 7.91 ± 3.78; 8.25 ± 2.72 and 8.10 ± 3.52, p-value <0.0001 in 2.5g, 5g and 10g dosage group. Handgrip strength demonstrated substantial improvements across all doses (p-value <0.0001) to 20.91 ± 5.57, 60.60%; 27.67 ± 7.82, 62.35%; 22.40 ± 8.65, 30.40%. The duration of low plank holds improved significantly across all doses (p-value <0.001) to 37.41 ± 15.13, 77.38%; 39.00 ± 17.00, 79.31% and 37.20 ± 20.09, 58.30%. Knee flexion and extension, hip abduction, adduction, internal rotation, and external rotation, were improved. Collagen supplementation is vital due to its natural decline with age. Furthermore, it has shown efficacy in reducing facial skin wrinkles, roughness, and scaliness, while improving skin elasticity, hydration, hair growth, hair density, hair thickness and nail health. No adverse events were reported during the study. PROCOL™, containing bovine collagen sourced from cow hides, has demonstrated safety, tolerability and effectiveness in enhancing joint health, aiding muscle development as a dietary supplement, and mitigating OA symptoms.

INTRODUCTION

As the aging population continues to grow, and people become increasingly health-conscious, there is a heightened interest in maintaining healthy skin. A variety of bioactive substances, including plant extracts, microbial metabolites, minerals, and vitamins, are being recognized for their ability to support and enhance skin health, helping individuals achieve their desired skin condition [1].

Collagen stands out as one of the most extensively distributed and plentiful proteins found in mammals. Commonly utilized types of collagen encompass I, II, III, IV, and various other collagen variants. As a structural protein, its significance lies in its role in organizing and maintaining the structural integrity and strength of various tissues. Beyond this, collagen also contributes to the support of connective tissues like tendons, skin, and teeth, while additionally playing a stabilizing role in cellular structures within body tissues, thereby enhancing their strength and stability [1]. The most predominant types of collagen namely Type I, Type II, and Type III, each possess distinct applications. Type I collagen, prominently found in marine collagen, is commonly employed in the composition of organic bone structures, guided tissue regeneration membranes, and various other applications. Type II collagen, derived from sources such as chicken and Bovine Collagen, plays a pivotal role in the constitution of cartilage, rendering it valuable for applications related to cartilage repair and the treatment of conditions like arthritis. Conversely, Type III collagen serves as the primary constituent of reticular fibers and is utilized in the development of haemostats and tissue sealants. Notably, a combination of Type I and Type III collagen can be extracted from porcine and Bovine Collagen sources, thereby broadening their potential applications [2].

In an extensive review conducted by Khatri M et al., which delved into the impact of collagen on the recuperation of joint injuries, the findings were notable. The research provided robust evidence supporting the effectiveness of collagen supplementation at daily doses ranging from 5 to 15 grams in improving both joint pain relief and functional recovery. Furthermore, collagen exhibited a significant, though moderate, enhancement in muscle recovery [3].

Osteoarthritis (OA) represents a distinct form of arthritis characterized by cartilage deterioration and bone restructuring. This condition encompasses synovial inflammation, joint degeneration, friction, and changes in subchondral bone [4,5]. Muscle weakness is a prevalent issue among individuals diagnosed with hip or knee OA. This reduction in muscle strength significantly contributes to the extent of pain and disability experienced by OA patients. Therefore, when it comes to managing OA, especially through exercise therapy, improving muscle strength is acknow ledged as a fundamental approach for reducing both pain and disability. Consequently, in studies evaluating the efficacy of various OA treatments, muscle strength is consistently chosen as a crucial parameter for assessment [6]. Collagen could serve as a safe and advantageous therapeutic supplement for managing symptoms related to both OA and osteoporosis [7,8]. Bovine bone is a prominent by-product within the bovine processing industry and has been extensively utilized as a primary source for obtaining premium-quality collagen. The primary biological impact of collagen peptides obtained from bovine bone primarily revolves around their advantageous influence on bone metabolism, encompassing the prevention of bone loss and enhancement of OA conditions [9]. Bovine Collagen is a product obtained from collagen peptides sourced from the hides of cows. The main aim of this study was to assess the impact of different dosages (2.5g, 5g and 10g) of collagen supplementation on OA symptoms and overall physical well-being, thereby investigating the impact of bovine collagen on muscle strength, skin, hair and nails.

METHODS

Study Design and Ethical Considerations

A prospective, post-approval, single-blinded, single-center, comparative, dose-response clinical safety and efficacy study, spanning a duration of 60 days, was conducted at NovoBliss Research Private Limited in Ahmedabad, Gujarat, India, with the primary objective of assessing the efficacy, tolerability, and safety profile of Bovine Collagen. The study was conducted adhering to ethical and regulatory guidelines, including the Declaration of Helsinki, the Indian Council of Medical Research (ICMR) 2006 guidelines for biomedical research, and Good Clinical Practice (ICH GCP R2) and the Indian GCP.

Prior to the initiation of the study, the research protocol [Version#01 (Final)], informed consent form [version#01 (Final)], case report form [version#01 (Final)] and other necessary documents were reviewed and a formal approval from an Independent Ethics Committee (IEC) was obtained on November 5, 2023. Subsequently, the study was registered with the Clinical Trial Registry India (CTRI) on November 9, 2022, bearing the registration number CTRI/2022/11/047149. Concurrently, it was also registered with Clinicaltrials.gov, with the trial identifier number NCT05613660. A written informed consent was obtained from subjects before enrolment.

Study Population

In the course of this study, a cohort of adult participants with Osteoarthritis were successfully recruited, aligning with the objective of including 22 individuals in each dose category. A total of 66 patients were initially enrolled, with 58 successfully completing the study. Subjects were selected through a screening process that considered criteria such as mild to moderate swelling, stiffness, reduced range of motion, and a diagnosis of OA. Individuals with osteoarthritis who had complaints of joint pain and stiffness, as indicated by their medical prescriptions and medical history, were included in the study.

The study subjects were stratified into three distinct groups based on the allocated dosages of Bovine Collagen, specifically 2.5 grams, 5 grams, and 10 grams. This categorization ensured that each group received a different dosage level of the experimental product.

Study Product

Test treatment is a high-quality Bovine Collagen product obtained from cow hides. Bovine collagen, derived from the skin, bones, and connective tissues of cattle, is rich in Type I and Type III collagen. These collagen types play crucial roles in maintaining skin elasticity, supporting joint health, and promoting overall well-being. Throughout the study, participants were asked to consume 1 scoop/sachet daily with approx. 250 mL water, for 8-weeks.

Selection criteria

The study enrolled adult male and non-pregnant/non-lactating female subjects aged 30 – 50 years with OA who had complaints of pain and stiffness in joints (based on their current prescription and medical history) and decreased range of motion. Female participants of childbearing potential with negative urine pregnancy test and subjects having complaints of hair fall and decreased hair growth during the screening visit were considered.

The study excluded subject having a score of at least "mild skin aging" based on PGA (Physician Global Assessment) at screening visit. Individuals with a known history of allergies or sensitivities to the test treatment ingredients. Furthermore, individuals with pre-existing or dormant dermatologic conditions such as psoriasis, rashes, eczema, seborrheic dermatitis, acne, or any other condition that could potentially interfere with the study outcomes, as determined by the Investigator, were not included.

Internal training and process validation

An internal training session was organized by a physiotherapist to impart training to the team with various scoring activities, tests and assessments, such as the Visual Analog Scale (VAS) scoring, and a range of muscle strength tests, including manual isometric muscle testing, hand grip strength assessment, upper body muscle strength (push-up), and the low plank hold.

NovoBliss Research also conducted an internal training and validation study for dermal assessment aimed at showcasing the various procedural steps, processes, and clinical practices involved in skin and nail assessment [10]. This training helped in maintaining consistency and accuracy in the evaluation procedures conducted during the study.

Study objective

The objective of the study was to evaluate the efficacy of Bovine Collagen in alleviating joint pain using the VAS scoring and to measure alterations in muscle strength, including handgrip, elbow flexion and extension, and knee flexion and extension strength. Furthermore, the Leeds Sleep Evaluation Questionnaires (LSEQ) was utilized to evaluate sleep quality. The study also involved collection of subjects' feedbacks on various aspects, including skin elasticity, suppleness, sleep quality, digestive and gut health, joint health, as well as the health of nails and hair, through hedonic questionnaires.

Efficacy Endpoints

Efficacy endpoints assessment included changes in muscle strength, pain and stiffness, and improvement in OA symptoms. Furthermore, including changes in facial wrinkles, fine lines in the Crow's feet region, and skin texture attributes like roughness, dryness, and smoothness, assessed using Visioscan® VC 20 Plus. Additionally, the analysis encompassed evaluations of changes in skin elasticity and hydration using DermaLab®Combo and MoistureMeterEPiD, respectively. The study delved into changes in hair thickness and density via CASLite Nova and assessed hair fall through the 60-second hair count method. Furthermore, the study investigated the impact of the test treatment on scalp hair growth from pre-treatment (4 days before Day 01 and Day 01) to post-treatment (Day 57 and Day 60) under the expert evaluation of dermatologists.

METHODOLOGY

A retrospective post hoc analysis was conducted on data from subjects of OA aged 30-50 years, having complaints of joint pain and stiffness. Information about the patients' demographics, initial pain and stiffness data assessed with VAS scoring, muscle stiffness, PGA score, and parameters of skin, hair and nails was gathered.

The study comprised six scheduled visits conducted according to a defined timeline. Day (-04) served for baseline muscle strength measurements before treatment. Day 01 enrolled participants and assessed hair growth and muscle strength. Day 10 and Day 30 monitored treatment progress. Day 57 included muscle strength assessments, tattoo application, and hair growth measurement. Finally, Day 60 marked the study's end with a comprehensive final evaluation, including muscle strength measurement.

Muscle strength assessment in this study involved a comparison of specific muscle groups on both sides of the body against resistance. The evaluation encompassed hand grip strength, measured using a CAMRY dynamometer to assess forearm muscle strength, upper body muscle strength determined by the number of push-ups performed within 60 seconds, and upper body muscle strength evaluated based on the duration of a low plank hold and change in pain

according to VAS(0-10cm). Furthermore, subjective perception questionnaires on treatment effects were administered by study staff after treatment consumption, offering valuable insights into the assessment of muscle strength, skin and nail indicating impact of the test treatment.

Statistical Analyses

Descriptive statistical analysis was utilized to provide an overview of continuous variables, which included summarizing metrics such as the observation count (N), mean, standard deviation (SD), median, minimum, and maximum values. Categorical variables were presented using frequencies and percentages, and relevant visual aids were incorporated when necessary. To assess significant changes between baseline and post-treatment measurements for continuous variables, paired t-tests were employed, enabling the detection of noteworthy differences and were presented as mean ± standard deviation. The statistical analyses were performed using R software (Version: 4.3.1) and GraphPad Prism (Version 9.5.1, build 733), with a significance threshold set at 5%.

RESULTS

In the study, a total of 66 subjects were enrolled, with an allocation of 22 subjects to each respective dosage/test treatment group. Among these, 58 subjects successfully concluded the study, and a post hoc analysis was performed on the data from the entirety of these 58 participants were incorporated into the subsequent statistical analysis. Among the enrolled subjects 39 (59.00%) were females and 27 (41.00%) were males (as shown in Table-1).

Table 1: Demographics details

Parameters / Statistics	PROCOL™ (2.5g) (N=22)	PROCOL™ (5g) (N=22)	PROCOL™ (10g) (N=22)
Age			
Mean (SD)	38.50 (5.60)	37.91 (6.14)	37.46 (5.56)
Gender			
Female	17 (77.27%)	10 (45.45%)	12 (54.55%)
Male	5 (22.73%)	12 (54.55%)	10 (45.45%)
Height (Cm)			
Mean (SD)	158.48 (8.98)	164.96 (7.74)	161.77 (9.93)
Weight (Kg)			
Mean (SD)	60.76 (15.31)	59.79 (12.58)	66.54 (10.06)
BMI (kg/m^2)			
Mean (SD)	24.42 (6.11)	22.03 (4.66)	25.59 (4.39)
Waist Circumference (inches)			
Mean (SD)	34.55 (4.72)	34.50 (4.11)	35.55 (3.71)
Hip Circumference (inches)			
Mean (SD)	37.02 (4.35)	36.27 (4.35)	39.14 (3.31)
Medical/ ConMed History (Yes/No)			
No	22 (100.00%)	22 (100.00%)	22 (100.00%)
Note: SD: Standard Deviation			

This post hoc analysis demonstrated significant improvements in upper body muscle strength, as evaluated through push-up performance, hand grip strength, low plank hold across all dosage groups (2.5 g, 5 g, and 10 g). On Day 10, there were remarkable increases in push-ups count in one minute from 3.36 ± 2.22; 3.56 ± 2.37 and 3.10 ± 2.53 at baseline to 4.77 ± 2.51, 41.96%, p-value <0.0001; 4.81 ± 2.48, 35.11%, p-value <0.001 and 4.26 ± 2.60, 45.81%, p-value <0.0001. By Day 30, these improvements escalated to 5.96 ± 3.20, 77.08%; (5.94 ± 2.46, 66.29%, and 5.65 ± 3.18, 82.26%; (p-value <0.0001). By Day 60, the enhancements significantly improved by >100% (p-value <0.0001) of 7.91 ± 3.78; 8.25 ± 2.72 and 8.10 ± 3.52. Hand Grip Strength, also displayed notable enhancements on day 10 from baseline of 13.02 ± 5.42; 17.05 ± 6.56 and 17.17 ± 8.43 with significant rise (p-value <0.01) to 17.24 ± 5.74, 32.49%; 22.95 ± 7.69, 34.66%, and 17.60 ± 7.42, 8.04% in the 2.5 g, 5 g and 10 g dosage groups, respectively. By Day 30, substantial improvements of 18.26 ± 5.30, 40.25%, p-value <0.00001; 25.69 ± 8.81, 50.73% and 20.22 ± 8.13, 17.76%; p-value <0.01 were evident in all dosage groups (2.5 g, 5 g and 10 g) relative to baseline measurements. Furthermore, on Day 60, highly significant improvements (p <0.0001) were observed, with substantial increases of 20.91 ± 5.57, 60.60%, 27.67 ± 7.82, 62.35%, and 22.40 ± 8.65, 30.40% in the 2.5 g, 5 g, and 10 g dosage groups, respectively, compared to baseline values. It's noteworthy that on Day 10, muscle strength assessed through the Low Plank exercise showed significant improvements (p-value <0.05) in hold time (seconds), from baseline 21.09 ± 7.51; 21.75 ± 11.02 and 23.50 ± 14.67 to 25.82 ± 10.96, 22.43%; 26.50 ± 13.97, 21.84% and 29.53 ± 22.00, 27.10% in the 2.5 g, 5 g and 10g dosage groups, respectively. By Day 30, further enhancements were evident, with significant increase in mean values (p-value <0.01) to 28.55 ± 11.14, 35.37%; 28.75 ± 12.75, 32.18% and 27.10 ± 15.35, 15.32% in the 2.5 g, 5 g and 10g dosage groups. On Day 60, highly significant improvements were observed (p-value <0.0001) with substantial increases of 37.41 ± 15.13, 77.38%; 39.00 ± 17.00, 79.31% and 37.20 ± 20.09, 58.30% in the 2.5 g, 5 g, and 10 g dosage groups, respectively, compared to baseline.

Table 2: Percentage Change from Baseline in Muscle Strength

Variables	Visit Days	PROCOL™ (2.5 g)	PROCOL ™ (5 g)	PROCOL ™ (10 g)
Push-ups in 60s	**Day 10**	41.96%↑	35.11%↑	45.81%↑
	Day 30	77.08%↑	66.29%↑	82.26%↑
	Day 60	135.42%↑	128.93%↑	161.29%↑
Hand grip Strength	**Day 10**	32.49%↑	34.66%↑	8.04%↑
	Day 30	40.25%↑	50.73%↑	17.76%↑
	Day 60	60.60%↑	62.35%↑	30.40%↑
Low Plank Hold	**Day 10**	22.43%↑	21.84%↑	27.10%↑
	Day 30	35.37%↑	32.18%↑	15.32%↑
	Day 60	77.38%↑	79.31%↑	58.30%↑

Furthermore, there was a significant reduction in both pain and stiffness, as assessed through the VAS Score. On Day 10, the 2.5g, 5g and 10g dosage groups experienced significant decreases from baseline (p-value <0.05) of 5.18 ± 0.59; 5.50 ± 0.89 and 5.80 ± 0.62 to 5.09 ± 0.53, 1.74%; 5.06 ± 1.00, 8.00%, and 5.63 ± 0.60, 3.62%, respectively.

Subsequently, by Day 30, further substantial reductions of 4.82 ± 0.59, 6.95%; 4.81 ± 0.91, 12.55% and 5.35 ± 0.67, 7.76% (p-value <0.05) were noted in the 2.5g, 5g and 10g groups, respectively. Finally, on Day 60, highly significant reductions (p-value <0.001) of 4.00 ± 1.02, 22.78%; 3.81 ± 1.11, 30.73% and 4.30 ± 1.22, 25.86% were observed overall dosage groups, respectively, indicating a progressive and substantial alleviation of pain and stiffness over time and with varying dosages.

In addition to the aforementioned assessments, muscle mobility was evaluated using manual isometric muscle testing, where various movements including flexion and extension of knee and abduction, adduction and rotation of hip were assessed.

The results indicated significant improvements in mobility across all dosage groups (2.5g, 5g and 10g), with the most substantial enhancements observed on Day 60 when compared to earlier time points. Bovine Collagen exhibited a positive impact on muscle mobility, leading to improvements in knee flexion and extension, hip abduction, hip adduction, as well as internal and external hip rotation.

After 60 days consumption of Bovine Collagen, subjects when asked about their quality of sleep using LSEQ, the score improved from baseline with mean change 4.5 ± 0.6; 4.38 ± 0.61 and 4.53 ± 0.59 to 7.91 ± 0.72; 7.82 ± 0.68 and 8 ± 0.68 respectively in all the dosage groups (Figure-1).

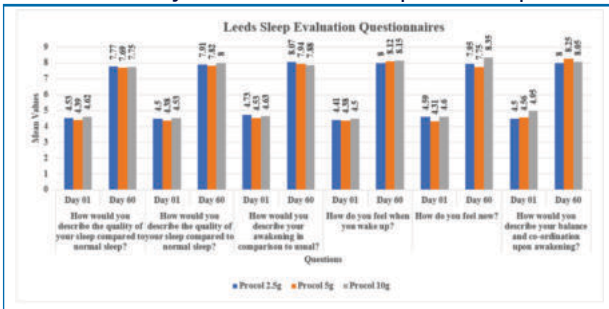

Figure 1: Leeds Sleep Evaluation Questionnaires

Changes in hair thickness (measured in micrometers, μm) was observed after treatment. At baseline, the mean hair thickness values were 15.32 ± 2.08 μm for 2.5g; 15.75 ± 2.41 μm for 5g and 16.20 ± 2.19 μm for 10g, which significantly improved (p-value <0.0001) with mean change 19.68 ± 2.75 μm, 28.46%, 20.06 ± 1.98 μm, 27.37% and 19.00 ± 1.21 μm, 17.28% at Day-60 (Table-3).

With regards to skin roughness, scaliness, wrinkles and smoothness using Visioscan VC 20®, the treatment effectively improves the roughness by Day-60 from 0.56 ± 0.44; 0.52 ± 0.37 and 0.52 ± 0.48 to 1.61 ± 0.97, >100%, p-values <0.001; 1.75 ± 1.14, >100%, p-value <0.001 and 1.84 ± 0.91, >100%, p-value <0.0001 also scaliness reduced from 4.26 ± 1.92; 5.51 ± 2.31 and 4.80 ± 2.03 to 1.41 ± 0.94, 66.90%, 1.34 ± 0.92, 75.68 and 1.26 ± 0.72, 73.75%; p-value <0.001 respectively. Additionally, wrinkles significantly reduced (p-value <0.0001) from baseline of 88.61 ± 29.23; 99.69 ± 34.74 and 103.66 ± 36.15 to 39.14 ± 4.63, 55.83%; 39.99 ± 7.14, 59.89%; 42.53 ± 6.95, 58.97% further smoothness improves from 330.19 ± 130.11; 348.94 ± 99.42 and 363.07 ± 147.04 to 189.37 ± 47.10, 42.65%; 193.34 ± 38.25, 44.59% and 214.25 ± 63.17, 40.99%; p-value <0.01 in all the dosage group (2.5g, 5g and 10g). Interestingly, at Day-60 Visco Elasticity improved (p-value<0.05) from 3.28 ± 1.58; 3.34 ± 1.20 and 3.42 ± 1.52 to 3.70 ± 1.47, 12.81% in 2.5g and to 3.71 ± 1.15, 11.08% in 5g.

The young's modulus improves from baseline of 1.96 ± 0.61; 2.12 ± 0.69 and 2.05 ± 0.74 to 2.02 ± 0.54, 3.06%; 2.38 ± 1.01, 12.26% and 1.78 ± 0.31, -12.68% respectively (Table-3). The moisture content of skin as measured by MoistureMeterEpiD (%water content (wc)) improves at Day-60 (p-value<0.0001) from baseline of 33.23 ± 7.37%wc; 33.84 ± 8.24%wc and 33.36 ± 7.05%wc by 14.32 ± 9.03%wc, 43.09%; 13.88 ± 10.48%wc, 41.02%; 10.16 ± 7.94%wc, 30.43% in all the three groups.

The hair falls count at baseline 47.64 ± 22.47; 23.63 ± 21.36 and 38.40 ± 32.06 decreases by -25.23 ± 15.61, 52.96%, p-value <0.0001; -11.38 ± 9.31, 48.16%, p-value <0.001 and -21.10 ± 20.60, 54.95%, p-value <0.001 at Day-60 in all the dosage group respectively.

Assessment of Hair pluck test found that anagen with sheath improves from baseline to Day-60 by 0.14 ± 2.01, 5.69% and 0.80 ± 2.78, 40% in 2.5g and 10g group. Telogen hairs significantly reduces (p-value<0.0001) at Day-60 from baseline of 42.46 ± 19.73; 42.87 ± 14.93 and 47.55 ± 13.40 to -23.11 ± 18.98, -54.43%; -23.49 ± 15.38, -54.79% and -33.00 ± 15.72, 69.40% in all the three group.

The assessment of skin PGA showed improvement at Day-60 when compared to the baseline, as determined using the Griffith scale.

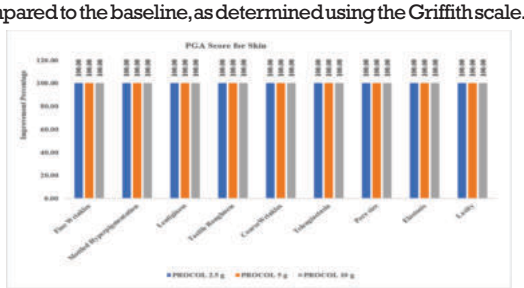

Figure 2: PGA Score for Skin

At Day-60 it was observed that a greater number of subjects were in Glogau Skin Age type II than in the baseline.

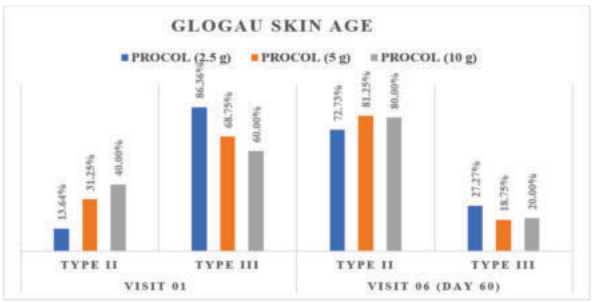

Figure 3: Glogau Skin Age

The assessment of the Hair Pull Test revealed that by Day-60, there was a noticeable improvement in hair strength for all subjects, with a 100% enhancement observed.

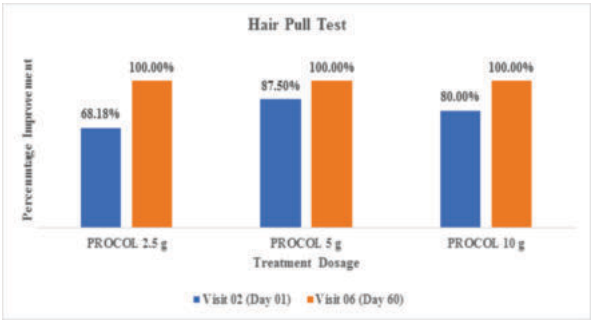

Figure 4: Hair Pull Test

The PGA score for nail appearance, evaluated by a dermatologist in terms of Lamellar Onychoschizia, Ridging, Longitudinal Splitting, Fragility/Breakage, Thickness of the nail, Surface Roughness, Raggedness, and Peeling, exhibited a reduction at both Day 30 and Day 60.

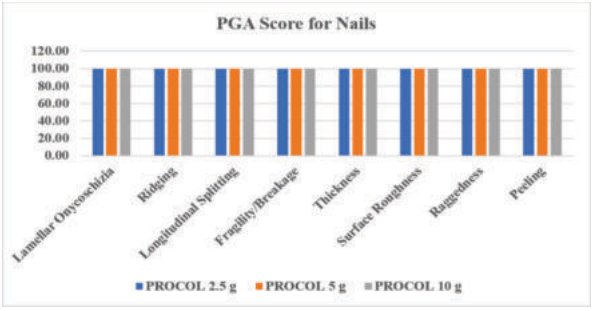

Figure 5: PGA Score for Nails

In all dosage groups, a remarkable outcome was observed at Day 60 from baseline, with 100% of the subjects achieving improved skin, as assessed by a Dermatologist Trained Evaluator using Investigator Global Assessment (IGA) Scoring for Acne. According to the subjective product perception assessment questionnaire results, all dosage groups reported 100% satisfaction with the usage and effectiveness of the treatment on Day 60 compared to the baseline. Throughout the study no adverse events were reported indicating the safety and tolerability of bovine collagen.

Table 3: Percentage Change from Baseline in Skin and Hair parameters

Percentage Change from Baseline				
Variables	**Visit Days**	**PROCOL ™ (2.5 g)**	**PROCOL ™ (5 g)**	**PROCOL™ (10 g)**
Crow's Feet Area Wrinkles	**Day 10**	29.21%↓	35.51%↓	34.69%↓
	Day 30	38.70%↓	45.90%↓	48.50%↓
	Day 60	55.83%↓	59.89%↓	58.97%↓

Roughness	**Day 10**	30.36%↑	23.08%↑	13.46%↑
	Day 30	87.50%↑	59.62%↑	88.46%↑
	Day 60	189.29%	236.54%↑	253.85%↑
Scaliness	**Day 10**	30.52%↓	40.47%↓	67.50%↑
	Day 30	41.08%↑	47.01%↓	45.42%↓
	Day 60	66.90%↑	75.68↓	73.75%↓
Smoothness	**Day 10**	12.83%↓	16.80%↓	18.79%↓
	Day 30	21.57%↓	25.57%↓	30.77%↓
	Day 60	42.65%↓	44.59%↓	40.99%↓
Skin Viscoelasticity	**Day 10**	0.31%↑	8.98%↑	6.14%↑
	Day 30	0.92%↑	2.40%↓	4.97%↓
	Day 60	12.81%↑	11.08%↑	8.19%↓
Skin Retraction time	**Day 10**	15.07%↓	14.07%↓	11.54%↓
	Day 30	19.60%↓	24.49%↓	17.16%↓
	Day 60	20.33%↓	23.02%↓	19.34%↓
Skin Young's module	**Day 10**	10.71%↓	6.13%↓	2.44%↓
	Day 30	7.14%↓	17.92%↓	11.71%↓
	Day 60	3.06%↑	12.26%↑	12.68%↓
Skin Hydration	**Day 10**	15.83%↑	20.95%↑	13.22%↑
	Day 30	26.72%↑	29.82%↑	25.99%↑
	Day 60	43.09%↑	41.02%↑	30.43%↑
Hair Density	**Day 10**	5.76%↑	3.44%↑	7.90%↑
	Day 30	13.63%↑	11.01%↑	17.63%↑
	Day 60	20.25%↑	21.62%↑	22.44%↑
Hair Thickness	**Day 10**	17.49%↑	15.87%↑	15.56%↑
	Day 30	21.93%↑	20.25%↑	15.43%↑
	Day 60	28.46%↑	27.37%↑	17.28%↑
Hair Fall	**Day 10**	20.91%↓	35.97%↓	29.06%↓
	Day 30	39.99%↓	35.46%↓	39.19%↓
	Day 60	52.96%↓	48.16%↓	54.95%↓

DISCUSSION

The existing body of literature strongly supports the beneficial effects of collagen supplementation across a range of health aspects. Collagen has shown promise in addressing various skin concerns, including the reduction of wrinkles and the enhancement of skin attributes such as elasticity, hydration, firmness, and brightness. In orthopaedic applications, collagen has been associated with positive outcomes, including increased bone strength, higher bone density, reduced extracellular matrix (ECM) degradation, improved joint stability, enhanced functional capacity, reduced stiffness, quicker muscle recovery, pain alleviation, and the attenuation of markers linked to joint cartilage degradation [11]. In a randomized controlled trial investigating the impact of collagen intake on muscle strength, a substantial enhancement in muscle strength was noted, particularly through a significant increase in hand-grip strength when compared to the group not receiving collagen peptide supplementation. These findings are consistent with the results from our present study, where the administration of Bovine Collagen for 60 days resulted in improved muscle strength, as evaluated through various measures, including the 60-second push up count, hand grip strength, and low plank hold, across different dosage groups. Notably, this improvement also correlated with a reduction in OA symptoms such as pain and stiffness [12].

In this study, we have demonstrated effectiveness of Bovine Collagen in enhancing mobility, which aligns with previous research indicating improved mobility and reduced pain with the use of oral collagen hydrolysate [13,14,15]. Our findings corroborate the results of a meta-analysis involving 5 randomized controlled trials (RCTs), which highlighted the significant reduction in stiffness and VAS pain scores associated with collagen supplementation [16]. Furthermore, our study aligns with previous research involving athletes, where the administration of collagen hydrolysate as a nutritional supplement over a 24-week period led to a reduction in joint pain [15]. Comparatively, this post hoc analysis adds to the growing body of evidence supporting the efficacy of collagen-based interventions, particularly in enhancing mobility and relieving joint-related discomfort.

Collagen therapies have been the subject of numerous clinical studies, showcasing their effectiveness in various applications, including enhancing skin moisturization, promoting skin flexibility, serving as a medical scaffold therapy, and addressing conditions such as Gastro esophageal Reflux Disease (GERD), OA, and Rheumatoid Arthritis (RA) [2]. For instance, in 2012, Schwartz and Park conducted a study involving 26 healthy women who received a daily dose of 1 gram of collagen. The results of this 12-week study revealed a notable reduction in skin dryness and wrinkles, underscoring the positive effects of collagen supplementation on skin health [17]. In a study investigating the impact of collagen on sleep, it was discovered that following the treatment, there was a 7% increase in the duration of sleep, this was similar to the present study where 60-day consumption of Bovine Collagen leads to improved sleep [18].

Consistent with this existing research, our present study provides compelling evidence of the effectiveness of Bovine Collagen in improving several skin parameters, such as roughness, scaliness, wrinkles, smoothness, appearance viscoelasticity, and moisture content, hair density, strength and nail parameters including PGA scoring. Additionally, our study highlights the positive impact of Bovine Collagen on hair density, hair fall, nail appearance, and acne severity. Notably, a study involving Bovine Collagen supplementation has previously demonstrated improvements in skin elasticity [9], a finding that aligns with our own results, where 60 days of Bovine Collagen administration significantly enhanced skin elasticity.

CONCLUSION

In conclusion, this conducted study firmly establishes Bovine Collagen as an exceptional health supplement derived from cow hides. The findings undeniably demonstrate the safety and effectiveness of this treatment in enhancing various health parameters, encompassing joint well-being and muscle strength, which improved the overall quality of life of OA patients. Furthermore, skin, hair, and nail parameters were significantly improved, indicating an additional benefit of bovine collagen. Remarkably, all study participants uniformly reported significant improvements in sleep quality, digestion, bowel regularity, gut health, and nail appearance, emphasizing Bovine Collagen as the preferred supplement for addressing these health-related concerns. The study's principal results indicated that all the dosage effectively excels in alleviating joint discomfort and augmenting muscle strength and improves skin, hair and nail health. These conclusions were also supported by both objective measurements and participant feedback, underscore the substantial potential of PROCOL™ as a safe, well-tolerated, and efficacious contributor to overall physical well-being, with a specific emphasis on enhancing skin, hair, and nail quality.

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