Research Article

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# A double-blind, placebo-controlled, randomised, clinical study on the effectiveness of collagen peptide on osteoarthritis

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## Abstract

**BACKGROUND: Recent studies show that enzymatically hydrolysed collagen, the collagen peptide, is absorbed and distributed to joint tissues and has analgesic and anti-inflammatory properties. A double-blind, placebo-controlled, randomised trial with collagen peptides isolated from pork skin (PCP) and bovine bone (BCP) sources was carried out to study the effectiveness of orally supplemented collagen peptide to control the progression of osteoarthritis in patients diagnosed with knee osteoarthritis. Improvement in treatment was assessed with reduction in Western Ontario McMaster Universities (WOMAC), visual analogue scale (VAS) and quality of life (QOL) scores from baseline to 13 weeks (Visit 7). Safety and tolerability were also evaluated.**

**RESULTS: There was significant reduction from baseline to Visit 7 in the primary end points of WOMAC and VAS scores and in the secondary end point of QOL score in subjects with PCP and BCP groups, while in subjects with placebo group the end point indices remained unaltered. Furthermore, all the score levels of WOMAC, VAS and QOL decreased significantly ($P < 0.01$) in the study group compared to placebo group in Visit 7.**

**CONCLUSION: The study demonstrated that collagen peptides are potential therapeutic agents as nutritional supplements for the management of osteoarthritis and maintenance of joint health.**


**Keywords:** collagen peptide; osteoarthritis; cartilage; clinical study

## INTRODUCTION

Osteoarthritis (OA) is the most common type of arthritis and the major cause of chronic musculo-skeletal pain and mobility disability in the elderly population worldwide. The characteristic features of this chronic, progressive and degenerative disorder of the entire joint include variable inflammation and changes in the structure of bone bordering the joint and in the protective cushion called articular cartilage. Clinical manifestations include joint pain, tenderness, limitation of movement, effusion and varying degrees of inflammation, and finally induce disability in many patients.

The principal components of articular cartilage are the insoluble fibrous protein collagen and the soluble proteoglycans. A complex organisation of collagen, proteoglycans and the fluid environment endows the tissue with the capacity for reversible deformability, a property essential for its physiological function. The integrity of cartilage tissue is dependent on the complex network of type II collagen, proteoglycans and accessory proteins such as fibronectin. These molecules are synthesised and integrated into the residual extracellular matrix (ECM) by chondrocytes. The loss of ECM in cartilage is associated with an increased cleavage of type II collagen by collagenase and an aggrecan cleavage along with the degradation of small proteoglycans.[1] Alterations in the collagen fibril network have been observed including extensive changes in the collagen fibril orientations, especially in the superficial zone and reduction in the collagen content.[2,3] Although the loss of aggrecan in articular cartilage is essential for the progression of OA, the final cartilage damage is inflicted by the loss of the collagen network.[4]

Current pharmacological treatments widely use non-steroidal anti-inflammatory drugs (NSAIDs) as therapeutic agents for OA despite their adverse effects on long-term usage. An alternative treatment with nutritional supplements with higher levels of safety and effectiveness attracts much attention. By nature nutritional supplements are better positioned to provide long-term health benefits.

Collagen-based peptides represent functional peptides that exhibit various physiological activities. Bone mineral density has been shown to be increased by the oral ingestion of gelatin.[5] Folk medicines always mention the positive influence of collagenous preparations as being beneficial to joint health, skin, hair and nails.[6–8]

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Several studies show that enzymatically hydrolysed collagen (known as gelatin hydrolysate or collagen hydrolysate or collagen peptide) is absorbed and distributed to joint tissues and has analgesic and anti-inflammatory properties. The protein has a typical and unique amino acid composition in that it is very rich in glycine, proline and hydroxyproline. Research in mice has demonstrated that after oral administration of radiolabelled gelatin hydrolysate the radioactivity was specifically found in cartilage.[9] Animal experiments have suggested that oral ingestion of collagen peptide might have beneficial effects on joint health such as OA. A recent study in animal models demonstrated that collagen peptide reduced the morphological changes associated with osteoarthritic cartilage destruction in knee joints.[10]

Being a protein with rich source of amino acids specifically found in collagen, it is worthwhile performing a clinical evaluation of the substance to understand the health benefits in the management of OA. Hence the present study was planned with an aim to assess the effectiveness of pork skin collagen peptide (PCP) manufactured from pork skin and bovine bone collagen peptide (BCP) in subjects with clinically diagnosed knee OA.

## MATERIALS AND METHODS

### Investigational products

PCP was supplied by Nitta Gelatin Inc., Japan, and BCP was sourced from Nitta Gelatin India Ltd, and placebo (maltodextrin) was purchased from Matsutani Chemical Industry Co. Ltd, Itami, Japan. The amino acid profiles in PCP and BCP are illustrated in Table 1.

**Table 1.** Amino acid composition in pork skin collagen peptide (PCP) and bovine bone collagen peptides (BCP)

| Amino acid | Composition (g kg$^{-1}$) dry basis | |
|---|---|---|
| | PCP | BCP |
| Valine | 0.277 | 0.277 |
| Tyrosine | 0.060 | 0.023 |
| Threonine | 0.219 | 0.236 |
| Serine | 0.413 | 0.373 |
| Proline | 1.620 | 1.550 |
| Phenylalanine | 0.256 | 0.249 |
| Methionine | 0.088 | 0.063 |
| Lysine | 0.414 | 0.436 |
| Leucine | 0.334 | 0.345 |
| Isoleucine | 0.136 | 0.154 |
| Hydroxylysine | 0.104 | 0.076 |
| 4-Hydroxyproline | 1.350 | 1.330 |
| Histidine | 0.101 | 0.070 |
| Glysine | 2.640 | 2.720 |
| Glutamic acid | 1.160 | 1.160 |
| Aspartic acid | 0.670 | 0.670 |
| Arginine | 0.910 | 0.900 |
| Alanine | 1.070 | 1.130 |

### Study design

A double-blind, placebo-controlled, randomised, clinical study in 30 subjects of both sexes between age group 30 and 65 years diagnosed with knee osteoarthritis [visual analogue scale (VAS) score $\geq 40$ and Kellgren–Lawrence grade 2 to 4] were enrolled for the study. Subjects were assigned to one of the two treatment groups through computer-generated randomisation code using SAS® software. The study protocol, informed consent document and case report together with all secondary documents used for the study were reviewed and approved by an independent ethics committee. The study was conducted in accordance with the ethical principles as laid out in the current version of the Declaration of Helsinki and ICH-GCP guidelines and was registered (No. CTRI/2009/091/000993) with the Clinical Trial Registry, India. The subjects were advised to consume the investigational product or placebo orally, 5 g dissolved in 250 mL water or milk in the morning and night after food.

Thirty subjects those who fulfilled the study criteria (vital signs, physical examination, pregnancy test, previous medical history, chest X-ray, electrocardiogram, urine examination, serology, haematological and biochemical parameters) and study specific parameters of VAS score, Western Ontario McMaster Universities (WOMAC) score, quality of life (QOL) score and X-ray findings were enrolled and underwent placebo run-in period for 7 days. Subjects took the following baseline therapy during the placebo run-in period:

- Tablet aceclofenac sodium – 100 mg in the morning and at night after food for 7 days
- Tablet pantoprazole – 40 mg oral dosage in the morning before food for 7 days
- Flufenamic acid gel in the morning and at night for 7 days
- Physiotherapy (WAX BATH for the Knee for continuous 3–5 days).
- Placebo 10 g per day (5 mg twice) in the mornings and at night after food for 7 days

After the completion of run-in period the subjects were randomised in a 2:1 ratio to receive either PCP or placebo as illustrated in Fig. 1. As per the randomised ratio, 20 subjects received PCP and 10 subjects received placebo for 13 weeks (91 days). Altogether, 30 subjects took the investigational product daily twice (5 g dissolved in 250 mL of milk or water) in the morning and at night after food for 13 weeks. Static quadriceps exercise was continued throughout the treatment period.

The treatment period was split into seven visits with an interval of 15 days. During the treatment period if extensive knee pain occurred, the subjects were prescribed tablet aceclofenac sodium 100 mg. The efficacy variables were measured using the questionnaire-based assessment of pain, stiffness and physical function were done using the WOMAC score, VAS score and QOL score. The primary efficacy end points are improvement in treatment with a reduction in the WOMAC score by 20 points or more from the baseline to final visit (Visit 7), reduction in VAS score by 40 mm or more from baseline to Visit 7 in 100 mm scale of measurement, and reduction in QOL score by 20 points or more from baseline to Visit 7.

The clinical laboratory evaluation and biochemical evaluation were done by blood and urine analysis to assess the safety of PCP. Vital signs such as physical functions and other observations related to safety were analysed by temperature, pulse rate, respiratory rate, systolic and diastolic blood pressure.

The same study has been applied in second set of 30 subjects who were given BCP (20 subjects) or placebo (10 subjects).

### Statistical analysis

The primary efficacy parameter was based on the change in WOMAC and VAS score compared to baseline data over 14 weeks

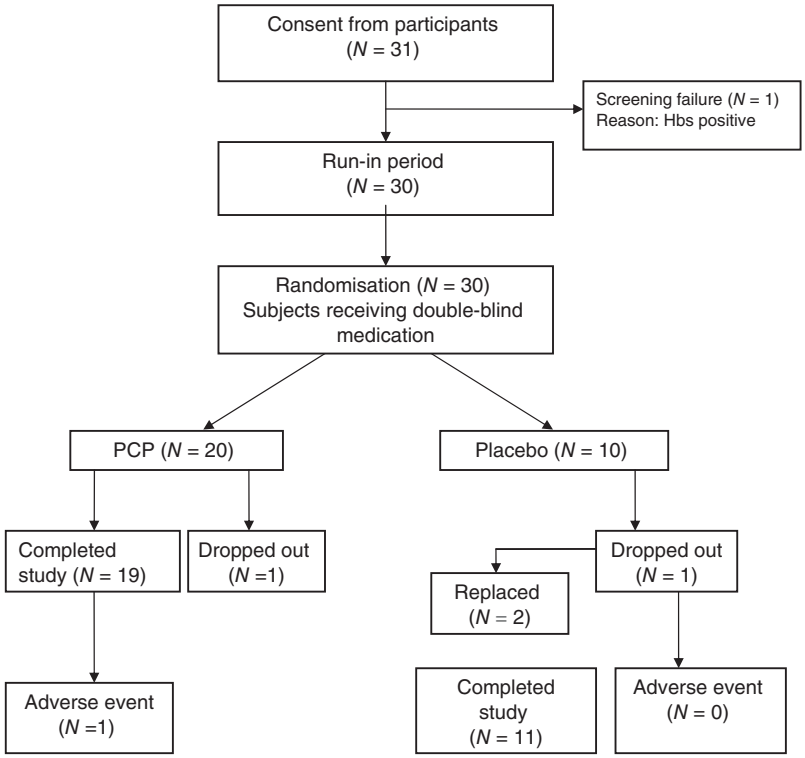


**Figure 1.** The selection method of subjects for clinical study and study design. The subjects were randomised after a 1 week run-in period with primary therapy into two arms of pork skin collagen peptide (PCP) and placebo in a 2:1 ratio. Nineteen subjects in the PCP group and all 11 subjects in the placebo group completed the study. Hbs: Hepatitis B.

study period. Kolmogorov–Smirnov Z test was performed to assess the normality of WOMAC and VAS score data. The Student paired *t*-test was applied for comparing the baseline and Visit 7 data. For non-normal data, the Mann–Whitney *U*-test was performed for comparison between study groups and the placebo group. The 95% confidence level (CL) around the mean score and the change in WOMAC and VAS score over 14 weeks study period was determined. Assessment of the secondary efficacy parameters was based on the change in QOL score over the 14-week study period compared to baseline data. The Kolmogorov–Smirnov *Z* test was used to assess the normality of QOL score data.

## RESULTS

The demographic characteristics of all subjects are recorded in Table 2. All the patients were advised to follow the routine diet whatever they practised at the time of inclusion into the clinical study. None of the patients involved in the clinical study showed any problems with their diet.

The changes of WOMAC score, VAS score and QOL score are given in Table 3. The WOMAC score, VAS score and QOL score have shown a prominent downward trend from baseline to Visit 7 in study group during the treatment period of 13 weeks. As shown in Table 3, there is significant reduction in the score levels of WOMAC ($P < 0.05$ in Visit 4, $P < 0.01$ in Visits 5–7), VAS ($P < 0.01$ in Visits 4–7) and QOL ($P < 0.01$ in Visits 4–7) in subjects with PCP when compared to placebo.

Furthermore, there was a significant reduction ($P < 0.01$) in the score levels of WOMAC, VAS and QOL at Visit 7 compared to the baseline score in subjects who had orally taken PCP, while there was no significant improvement in subjects who had taken placebo. The results further authenticate the role of PCP in improving the status of OA condition.

**Table 2.** Demographic data of subjects selected for clinical study

| | Study I (PCP) | | Study II (BCP) | |
|---|---|---|---|---|
| Variable | Study group (*N* = 19) | Placebo (*N* = 11) | Study group (*N* = 19) | Placebo (*N* = 11) |
| Sex | | | | |
| Male | 2 | 1 | 8 | 4 |
| Female | 17 | 10 | 11 | 7 |
| Height (cm) | | | | |
| Mean | 158 | 159 | 160 | 159 |
| Std | 6.7 | 7.8 | 8.7 | 7.4 |
| Min | 145 | 140 | 144 | 146 |
| Max | 171 | 160 | 175 | 171 |
| Weight (kg) | | | | |
| Mean | 64.5 | 58.5 | 65.6 | 65.2 |
| Std | 7.8 | 5.4 | 8.2 | 9.0 |
| Min | 55 | 49 | 53 | 52 |
| Max | 82 | 66 | 80 | 78 |
| BMI | | | | |
| Mean | 26.1 | 23.1 | 25.9 | 25.8 |
| Std | 3.8 | 1.9 | 3.3 | 3.3 |
| Min | 21.1 | 18.6 | 21.3 | 20.3 |
| Max | 33.9 | 26.2 | 33.3 | 32.3 |

**Table 3.** Changes of primary efficacy parameters for WOMAC and VAS and secondary end point parameter for QOL

| | WOMAC score (points) | | VAS score (points, in mm scale) | | QOL score (points) | |
|---|---|---|---|---|---|---|
| Visit | Placebo ($N = 11$) | PCP ($N = 19$) | Placebo ($N = 11$) | PCP ($N = 19$) | Placebo ($N = 11$) | PCP ($N = 19$) |
| Baseline | 47.3 ± 8.6 | 47.2 ± 9.8 | 60.0 ± 6.3 | 63.2 ± 10.6 | 53.3 ± 8.8 | 53.4 ± 10.4 |
| Visit 1 | 39.9 ± 8.7 | 35.4 ± 8.1 | 42.7 ± 13.5 | 44.2 ± 10.7 | 44.2 ± 9.8 | 39.8 ± 8.4 |
| Visit 2 | 42.6 ± 9.4 | 39.4 ± 9.4 | 52.7 ± 12.7 | 51.1 ± 9.4 | 47.9 ± 10.4 | 44.5 ± 9.8 |
| Visit 3 | 43.8 ± 8.7 | 37.8 ± 9.5 | 50.0 ± 12.6 | 46.8 ± 12.0 | 48.8 ± 9.8 | 42.4 ± 10.1 |
| Visit 4 | 43.6 ± 8.0 | 36.1 ± 9.6$^{*}$ | 50.0 ± 10.0 | 40.5 ± 11.8$^{**}$ | 48.6 ± 8.7 | 40.1 ± 10.1$^{**}$ |
| Visit 5 | 45.6 ± 8.1 | 34.7 ± 9.2$^{**}$ | 50.9 ± 12.2 | 38.9 ± 11.0$^{**}$ | 50.7 ± 9.1 | 38.6 ± 9.9$^{**}$ |
| Visit 6 | 43.6 ± 9.8 | 32.7 ± 9.5$^{**}$ | 54.5 ± 13.7 | 36.3 ± 13.8$^{**}$ | 49.0 ± 11.0 | 36.3 ± 10.4$^{**}$ |
| Visit 7 | 45.5 ± 9.4 | 31.1 ± 9.8$^{**\dagger}$ | 57.3 ± 13.5 | 31.1 ± 15.2$^{**\dagger}$ | 51.2 ± 10.7 | 34.3 ± 10.8$^{**\dagger}$ |

The results are the scores from 30 subjects (19 in PCP group and 11 in placebo group) participated in the study for seven visits once in 15 days during the 13-week study period.
Data are expressed as mean ± standard deviation (SD).
$^{*}P < 0.05$ vs. placebo in WOMAC score, VAS score or QOL score at the same visit.
$^{**}P < 0.01$ vs. placebo in WOMAC score, VAS score or QOL score at the same visit.
$^{\dagger}P < 0.01$ vs. Baseline in WOMAC score, VAS score or QOL score.

**Table 4.** Response ratio of subjects who have shown the study efficacy improvement in WOMAC, VAS and QOL scores

| | WOMAC score | | VAS score | | QOL score | |
|---|---|---|---|---|---|---|
| Assessment | Placebo ($N = 11$) | PCP ($N = 19$) | Placebo ($N = 11$) | PCP ($N = 19$) | Placebo ($N = 11$) | PCP ($N = 19$) |
| Percentage of efficacy improvement$^{*}$ | 0% | 63.2 | 0% | 63.2 | 9% | 63.1 |

$^{*}$Efficacy improvement is reduction in WOMAC score by 20 points or more from baseline to final visit (Visit 7), in VAS score by 40 points or more from baseline to Visit 7 and in QOL score by 20 points or more from baseline to Visit 7.

This observation is in correlation with the response ratio of subjects participated in the study. A total of 63% of subjects who have taken PCP have shown efficacy improvement in WOMAC, VAS and QOL score levels while the placebo group could not demonstrate such an efficacy improvement in all the score levels, as shown in Table 4.

The same study with BCP demonstrated similar results (Table 5) as that observed in study with PCP. The results further affirm that the efficacy behaviour of collagen peptide is similar (Fig. 2), whether the source of origin of peptide is from pork skin or bovine bone.

## Biochemical evaluations

As part of safety assessment, laboratory analysis was performed for the various biochemical parameters in serum and urine. The results of the baseline and Visit 7 are shown in Table 6. Other than some minor changes none of the biochemical parameters showed any significant variation in the results during the study period. The minor changes observed were not clinically significant. All the data were statistically analysed and found no significant differences from the normal range in PCP and placebo groups. Data are not shown, but BCP also achieved a similar result. These findings demonstrated the safety of PCP and BCP in humans. Moreover the

**Table 5.** Changes of primary efficacy parameters for WOMAC and VAS and secondary end point parameter for QOL

| | WOMAC score (points) | | VAS score (points, in mm scale) | | QOL score (points) | |
|---|---|---|---|---|---|---|
| Visit | Placebo ($N = 10$) | BCP ($N = 18$) | Placebo ($N = 10$) | BCP ($N = 18$) | Placebo ($N = 10$) | BCP ($N = 18$) |
| Baseline | 50.1 ± 14.7 | 50.3 ± 9.6 | 62.0 ± 14.0 | 66.0 ± 12.3 | 56.3 ± 15.4 | 56.9 ± 9.9 |
| Visit 1 | 35.3 ± 7.4 | 38.1 ± 7.7 | 50.0 ± 12.5 | 40.0 ± 13.4 | 40.3 ± 7.4 | 42.1 ± 7.9 |
| Visit 2 | 45.6 ± 13.9 | 38.5 ± 8.3 | 52.0 ± 12.3 | 44.5 ± 11.5 | 50.8 ± 14.3 | 42.9 ± 8.7 |
| Visit 3 | 47.4 ± 17.9 | 34.8 ± 8.6 | 51.0 ± 17.3 | 38.5 ± 11.8 | 52.5 ± 18.6 | 38.7 ± 8.9 |
| Visit 4 | 46.9 ± 18.3 | 32.9 ± 9.2$^{**}$ | 53.0 ± 14.9 | 39.5 ± 10.5$^{**}$ | 52.2 ± 19.2 | 36.8 ± 9.3$^{**}$ |
| Visit 5 | 45.2 ± 17.5 | 31.8 ± 9.6$^{**}$ | 52.0 ± 13.2 | 36.5 ± 11.4$^{**}$ | 50.4 ± 17.9 | 35.4 ± 9.8$^{**}$ |
| Visit 6 | 45.9 ± 18.6 | 29.1 ± 10.0$^{**}$ | 54.0 ± 19.6 | 32.0 ± 10.6$^{**}$ | 51.3 ± 19.9 | 32.3 ± 10.2$^{**}$ |
| Visit 7 | 47.3 ± 19.4 | 25.8 ± 11.3$^{**\dagger}$ | 55.0 ± 20.1 | 28.0 ± 10.9$^{**\dagger}$ | 52.8 ± 20.9 | 28.7 ± 11.4$^{**\dagger}$ |

The results are the scores from 28 subjects (18 in BCP group and 10 in placebo group) participated in the study for seven visits once in 15 days during the 13-week study.
Data are expressed as mean ± standard deviation (SD).
$^{**}P < 0.01$ vs. placebo in WOMAC score, VAS score or QOL score at the same visit.
$^{\dagger}P < 0.01$ vs. Baseline in WOMAC score, VAS score or QOL score.

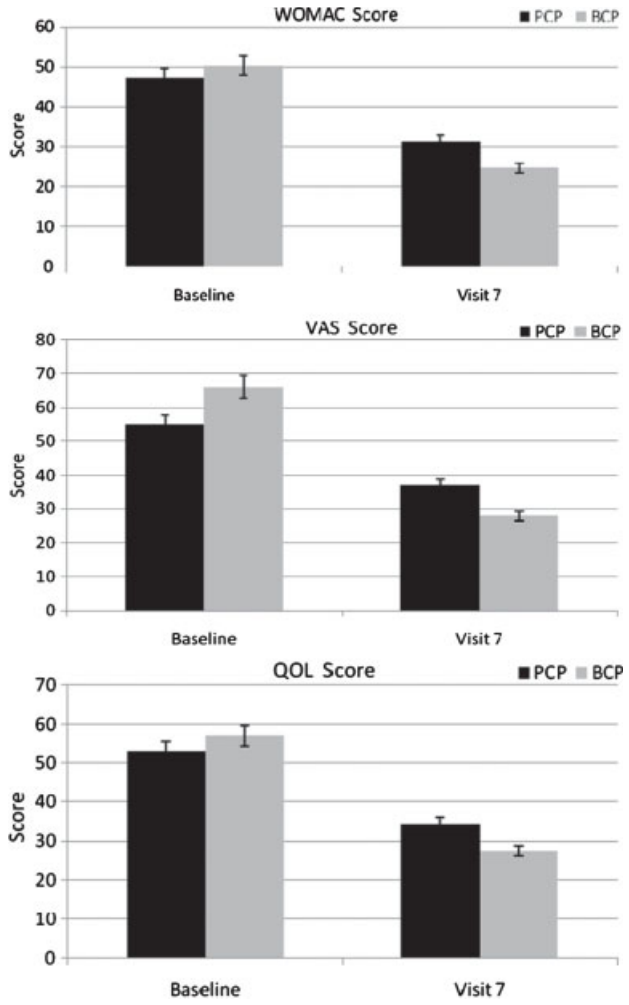


**Figure 2.** Comparison of Western Ontario McMaster Universities (WOMAC), visual analogue scale (VAS) and quality of life (QOL) scores in the pork skin collagen peptide (PCP) and bovine bone collagen peptide (BCP) groups at baseline and Visit 7. Each bar represents the average score with standard error.

US Food and Drug Administration (US FDA) has classified gelatin and collagen peptide as a Generally Recognised as Safe (GRAS) product.

### Adverse events

Among 20 subjects treated with PCP, only one experienced an adverse event of allergic peripheral oedema. The adverse event was reported to be mild in nature and was relieved with concomitant medication. Among 20 subjects treated with BCP, three subjects experienced adverse events such as vomiting, diarrhoea and common cold. Cold and vomiting were reported as mild while diarrhoea was reported as moderate and was cured by medical intervention.

All the adverse events had an unlikely relationship with investigational products and upon re-challenging the investigational products, the events did not re-appear.

## DISCUSSION

The present study demonstrated a significant change in the status of OA condition of patients orally administered with PCP or BCP compared to placebo group. Pain stiffness of joints, reduced movement of joints and physical disabilities are the major clinical manifestations in OA. The study carried out in clinically diagnosed subjects having knee OA demonstrated that both PCP and BCP are effective nutritional supplement to improve the overall physical discomforts resulting from the OA. Collagen peptides from two sources have been considered in this study to evaluate whether collagen peptides prepared by the same process from different sources would have the similar efficacy on the management of a human population with OA. This study is the first to compare collagen peptides from different sources. The study clearly demonstrated that, irrespective of the source of collagen peptides, the efficacy level remains the same. A recent study by Trc and Bohmova[11] compared the efficacy and tolerance of hydrolysed collagen and glucosamine sulphate treatment in knee OA. In their multicenter, randomised, double-blind study the subjects were given hydrolysed collagen at a dose of 10 g $day^{-1}$ and glucosamine sulfate 1.5 g $day^{-1}$ for 90 days. The efficacy was measured by WOMAC and VAS score analysis. According to the study results hydrolysed collagen shows superior improvement over glucosamine sulfate. Reduction of the WOMAC and VAS indices has been observed in 80.8% of study population who were orally supplemented with hydrolysed collagen while only 46.6% of study subjects in glucosamine sulfate have shown reduction. Moskowitz,[12] in his review on role of collagen peptide in bone and joint disease concluded that collagen peptide oral consumption in a daily dose of 10 g will have a therapeutic effect on the indications of OA and osteoporosis. In a review of clinical and preclinical studies on collagen peptide Bello and Oesser[13] explained the clinical evidence for the effectiveness of collagen peptide in the treatment of OA. The results of the present study with PCP are in accord with these observations.

The mechanism of action of collagen peptide has been extensively studied.[14–18] Experimental investigations have demonstrated that the degradation products of the collagen are principally able to influence cell metabolism.[19] Studies with labelled collagen peptide have shown that a significant amount of the peptide could be detected in skin and cartilage tissue after one single administration, indicating an accumulation of these peptides within the connective tissue.[9] The study demonstrated the intestinal absorption and cartilage accumulation of collagen peptide. Thus the potential role of collagen peptide in repair of damaged cartilage could be associated with the accumulation of orally administered collagen peptide. Cell culture experiments investigating the efficacy of collagen peptide on the biosynthesis of articular chondrocytes revealed that the treatment of cartilage cells with collagen peptide induced a statistically significant dose dependent increase in type II collagen synthesis of chondrocytes compared to the untreated controls.[19] The major component of collagen peptide that remained in the blood was identified as Pro–Hyp dipeptides.[14] Nakatani *et al.*[20] concluded that Pro–Hyp,a dipeptide in PCP, is an important factor that regulates chondrocyte differentiation and plays a key role in the maintenance of mature chondrocytes in cartilage. They hypothesised that Pro–Hyp in collagen peptide and its regulatory mechanism seem to explain the therapeutic effect of collagen peptide in improving joint conditions. Being one of the most important symptoms, pain reduction indirectly indicates the mark of improvement in joint conditions in patients with OA. Thus the administration of collagen peptide has much relevance with regard to reduction of pain in a patient with OA. As discussed previously, the improvement could be associated with the initiation of the repair process by

  

**Table 6.** Biochemical evaluation of subjects participated in the clinical study

| Biochemical analysis | Unit | Placebo | | Pork collagen peptide | |
|---|---|---|---|---|---|
| | | Baseline | Visit 7 | Baseline | Visit 7 |
| Urea | $\mu mol\ L^{-1}$ | 10.4 ± 3.3 | 9.1 ± 2.0 | 10.4 ± 3.3 | 8.6 ± 2.1 |
| Uric acid | $\mu mol\ L^{-1}$ | 179.4 ± 43.8 | 225.3 ± 46.4 | 221.1 ± 77.7 | 247.1 ± 44.5 |
| Creatinine | $\mu mol\ L^{-1}$ | 79.5 ± 26.0 | 64.9 ± 16.2 | 79.7 ± 25.3 | 73.2 ± 19.1 |
| Total bilirubin | $\mu mol\ L^{-1}$ | 7.2 ± 2.6 | 9.9 ± 6.3 | 6.4 ± 2.6 | 8.1 ± 4.4 |
| Direct bilirubin | $\mu mol\ L^{-1}$ | 2.4 ± 1.3 | 3.3 ± 1.5 | 3.1 ± 2.1 | 3.4 ± 1.7 |
| SGOT | $U\ L^{-1}$ | 24.0 ± 6.0 | 25.9 ± 6.1 | 23.8 ± 7.5 | 30.0 ± 13.7 |
| SGPT | $U\ L^{-1}$ | 21.0 ± 7.6 | 17.5 ± 8.9 | 21.6 ± 8.9 | 24.4 ± 17.0 |
| ALP | $U\ L^{-1}$ | 252.8 ± 65.9 | 186.9 ± 67.3 | 230.5 ± 82.6 | 211.4 ± 84.7 |
| Random blood sugar | $mmol\ L^{-1}$ | 6.4 ± 2.1 | 6.5 ± 3.8 | 6.3 ± 3.7 | 5.9 ± 1.3 |
| Total cholesterol | $mmol\ L^{-1}$ | 5.6 ± 0.9 | 4.6 ± 0.9 | 5.3 ± 0.8 | 4.5 ± 1.3 |
| Protein | $g\ L^{-1}$ | 73.6 ± 4.7 | 74.3 ± 3.8 | 74.4 ± 3.6 | 75.4 ± 4.4 |
| Albumin | $g\ L^{-1}$ | 44.3 ± 2.7 | 44.1 ± 2.9 | 43.1 ± 2.6 | 42.7 ± 4.2 |

Data are expressed as mean ± standard deviation (SD).
ALP, Alkaline Phosphatase; SGOT, Serum Glutamic Oxaloacetic Transaminase; SGPT, Serum Glutamic Pyruvate Transaminase.

accumulation of collagen peptide in cartilage tissue. The accumulated collagen peptide helps to maintain structure and function of cartilage, which in turn results in joint comfort and subsequent improvements in pain. These results clearly indicate that collagen peptide, irrespective of the source – namely pork skin or bovine bone – has a stimulatory effect on important molecules of ECM, namely proteoglycans, and thus might be of therapeutic relevance to slow down or even halt the progression of degradation of articular cartilage tissue in OA.

## CONCLUSION

The study clearly demonstrates that both PCP and BCP are effective supplements for the improvement in overall physical problems associated with OA and thereby help to improve the quality of life. It is hypothesised that the supplementation of collagen peptide regulates chondrocyte differentiation and stimulates synthesis of proteoglycans, resulting in the initiation of repair processes in cartilage tissue.

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