White Paper

5 Year Clinical Results With the BioPoly® Patella Implant
- An Interim Report

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Abstract

Background: Focal chondral and osteochondral lesions of the patella are common in patients with anterior knee pain. Treatment of these lesions is associated with variable outcomes, especially for the older patient population. We conducted a non-controlled clinical trial with the BioPoly® Patella Implant to assess the change in patient reported outcomes from baseline pre-op.

Methods: We performed an open label, prospective, consecutive series, single-arm study. Eleven patients with focal cartilage lesions of the patella were treated with the BioPoly Patella Implant. Patient reported outcome scores (Knee Osteoarthritis Outcome Score (KOOS), Visual Analog Scale Pain (VAS), Kujala (or Anterior Knee Pain Scale), Medical Outcomes Study Short Form-36 (SF-36), and Tegner Activity) were used to assess the patients at pre-operative, 6 months, 1 year, 2 year, 3 year, 4 year, and 5 year timepoints. Statistical comparisons were made between each timepoint and the baseline pre-operative timepoint.

Results: We found clinically and statistically significant improvements from 6 months to 5 years in KOOS subcategories of Symptoms, Pain, Activities of Daily Living, Quality of Life, and in the Overall KOOS score. VAS Pain and Anterior Knee Pain Scale (i.e. Kujala) scores resulted in similar improvements to 4 years and trending significance at 5 years. Two patients are due to hit the 5-year timepoint and the increased sample size is expected to push any trending pain data into significance.

Conclusions: The BioPoly Patella Implant is safe and provides significantly improved knee function and pain reduction by six months and this improvement is sustained to 5 years post-surgery. Patients with the BioPoly Patella Implant return to significantly higher levels of activity than they were capable of prior to surgery.

Level of Evidence: Therapeutic Level II.

Introduction:

Articular cartilage injuries in the patella are a common cause of pain anterior knee pain, swelling, and disability. Because full-thickness chondral defects do not heal spontaneously, surgical intervention is routine. First line treatments for young patients with localized cartilage defects aim to repair or replace the diseased tissue with healthy cartilage to restore the joint surfaces. As such, microfracture, autologous chondrocyte implantation, and osteochondral transplantation are employed to suspend disease progression. These therapies are particularly attractive because of their tissue-sparing nature. Since removal of cartilage and bone is restricted to the diseased area, treatment failure can be addressed with a wide variety of subsequent surgical options. For this reason, high failure rates are tolerated. For example, primary micro-fracture with no concomitant surgeries has 95% survivorship at 4 years and 92% at 7 years[1]. Further, some authors suggest that microfracture in patients >40 years old may only have the potential to relieve pain for some years or to delay the implantation of an endoprosthesis[2]. Patients who have under-gone traditional ACI in the patella have similar results. In a case report by Kreuz et. al. on graft hypertrophy after traditional ACI, 50% of 18 patella implants developed hypertrophic changes and 28% needed surgical intervention[3]. When compared to total knee arthroplasty (TKA), the gold standard with respect to consistent positive outcomes in the treatment of knee osteoarthritis, the probability of treatment success for cartilage repair procedures (microfracture, ACI, osteochondral trans-plant) is reduced. TKA has 5- and 10-year survival rates at 98% and 96%[4,5,6]. It would be advantageous to have a tissue sparing implant for the permanent replacement of localized cartilage defects with outcomes similar to those of TKA.

The BioPoly® Patella Implant is a long-term, surgically invasive device indicated for the replacement of symptomatic focal lesions located in the facets of the patella. The implant is a 'partial hemiarthroplasty' as it is used to only replace a limited diseased portion (partial) of one joint surface (hemi) and is not appropriate for the treatment of generalized degenerative or autoimmune joint disease. The aim of this open label, prospective, consecutive series, single-arm study was to assess the post-operative clinical outcomes of patients treated with the implant and to make comparisons with pre-operative status.

The BioPoly Patella Implant is manufactured from a micro-composite of UHMWPE and Hyaluronic Acid, known as BioPoly®. Four sizes (15mm and 20mm diameter at 3.5mm and 4.5mm thicknesses) were used in this study (**Figure 1**), and the device was intended to articulate with distal femur cartilage.

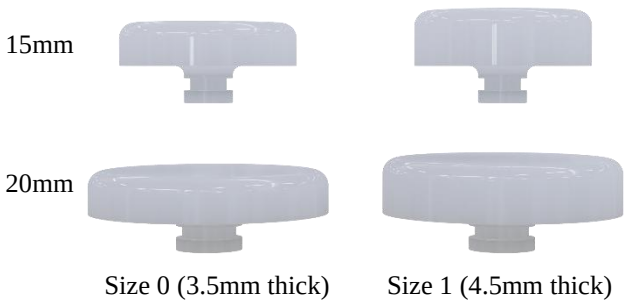

Figure 1: BioPoly Patella Implant Sizes

Methods:

The clinical investigation was designed as a multi-center, open label, consecutive series, non-randomized study. The primary end-points were KOOS, Kujala, VAS Pain, SF-36, and Tegner Activity scores with assessments occurring at 6 months, 1 year, 2

years, 3 years, 4 years, and 5 years. Any complications were carefully assessed during the study to evaluate implant safety. The study was conducted at three UK centers, ensuring that Good Clinical Practice guidelines were followed. With significance established at $p < 0.025$ and power at 0.90, the number of patients required for study enrollment was determined to be ten in order to demonstrate a clinically meaningful improvement, using a minimum KOOS QoL increase of 15 points at the 2-year time point as the basis for this calculation. Informed consent was obtained for all patients, and the clinical protocol and informed consent were approved by the London-Hampstead Research Ethics Committee (15/LO/1680). Patients with symptomatic focal cartilage defects in the patella were enrolled according to the inclusion and exclusion criteria listed below (**Table 1**).

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria*	Exclusion Criteria
• Age 21 years and older • Cartilage lesion(s) located in the facets of the patella that have failed prior therapy (conservative or surgical) • Symptomatic lesions classified as ICRS* grade 2, 3, or 4 • Lesion size may not exceed 3.1 cm^2 and must be circumscribed by a 15 mm or 20 mm circle of normal or nearly normal (ICRS Grade 0 or 1) cartilage, with an overall depth less than 4 mm from the articulating surface • Subchondral bone quality sufficient to support the implant • Understanding and willingness to comply with the post-operative rehabilitation instructions and follow-up visits.	• Body mass index (BMI) ≥ 35 • Generalized degenerative or autoimmune arthritis • Gout • Uncorrected chronic malalignment of the patella† • Uncorrected ligamentous instability† • Kissing lesion on femur • More than one implant required to accommodate lesion • Allergy to ultra-high molecular weight polyethylene (UHMWPE), or hyaluronan/hyaluronic acid (HA) • Use with opposing articulating femoral components • Any concomitant painful or disabling disease of the spine, hips, or lower limbs that would interfere with evaluation of the affected knee • Pregnant, prisoner, vulnerable population, unable to provide informed consent

*ICRS = International Cartilage Repair Society. †If corrected during surgery, BioPoly implantation is not excluded.

At the pre-operative visit, patient history and examination were recorded along with the following outcome measures: Knee Osteoarthritis Outcome Score (KOOS)[7], Kujala, Visual Analog Scale Pain Score (VAS Pain)[8], Medical Outcomes Study Short Form 36 (SF-36)[9], and Tegner Activity Score[10]. Radiographs or other imaging of each patient were obtained as required. During surgery, standard surgical forms were collected. Follow-up visits were conducted at 6 months, 1 year, 2 years, 3 years, 4 years, 5 years where patient outcomes and any complications were recorded.

The ethics approved surgical technique for the BioPoly Patella Implant (Manufacturer: BioPoly LLC, 7136 Gettysburg Pike, Fort Wayne, IN 46804) was used in order to prepare the surgical site and place each implant. The implantation site was prepared using a simple, bone-sparing technique that establishes the correct implant orientation and depth relative to the surrounding patient anatomy. Once the implantation site was deemed appropriate, the BioPoly Patella Implant was cemented into place, per the cement manufacturer's instructions.

A four-phase rehabilitation protocol (**Appendix 1**) was designed to return patients

to full activity within a matter of weeks. The protocol allows for immediate weight bearing and unrestricted range of motion as tolerated with return to full activity by 8 to 11 weeks. This differs from the suggested rehabilitation protocols for microfracture or other biological treatments which often recommend return to full activity 6 to 8 months post-surgery.

Each clinical outcome score was compared to its pre-operative value at 6 months, 1 year, 2 years, 3 years, 4 years, and 5 years, and one-sided, paired, one-tailed t-tests ($\alpha = 0.025$) were used to examine for statistically significant improvement from baseline.

Patient Population

The mean age of the population studied was 45.8 years, and the mean treated defect size was 2.64 ± 0.69 cm^2. For more information regarding the patient population and demographics, please refer to the table (**Table 2**) below.

Table 2: Patient Characteristics

Number of patients, n	11	Defect size, mean ± SD (cm^2)	2.64 ± 0.69
Age, mean ± SD, years	45.8 ± 9	Right/Left Knee	54.5%/45.5%
Age ≤ 40 years, n (%)	4 (36.4%)	Medial/Lateral	72.7%/18.2%
Gender	Female 7 Male 4	BMI*, mean ± SD, kg/m^2	29.0 ± 3.3
Previous knee surgery, n (%) Shaving, n (%) Other, n (%)	6 (54.6%) 5 (45.5%) 1 (9.1%)	Type of Injury Non-Trauma – Gradual, % Trauma - Non-Contact, % Trauma – Contact, %	 81.8% 9.1% 9.1%
Contralateral Knee Status$^+$ Normal/Nearly Normal, %	 90.9%	Activity at Injury ADL% / Work%*	 90.9% / 9.1%
*BMI = Body Mass Index, ADL = Activities of Daily Living $^+$Partial patient data, percentage is of all available patient information, not all patients			

Patient Disposition

A total of 12 patients were enrolled and/or screened. Following pre-treatment withdrawals, the treated population consisted of 11 patients (**Figure 2** below). Of the 11 patients who were treated, 7 were female and 4 were male. Approximately 18% of included defects required the 15 mm Size 0 implant, 18% required the 15 mm Size 1 implant, and 64% required the 20 mm Size 0 implant. The 20mm Size 1 implant was not used in the study; however, the only difference between Size 0 and Size 1 is 1mm in thickness, and its use is dependent on cartilage thickness. The depth of the implant relative to the articular cartilage is identical for Size 0 and Size 1, and the fixation is identical. The 15mm Size 0 and Size 1 were implanted in the study and both implant thicknesses performed without issue. Interestingly, 45.5% (n=5) of the cohort had previous cartilage shaving surgery. No patients required corrective procedures during implantation of the BioPoly device. By 2 years, one patient chose to withdraw from the study due to no adverse effects, after reporting clinically significant improvements in most clinical outcome scores over their pre-op condition. One patient was revised at 21 months post-surgery due to the onset of severe osteoarthritis in a different compartment from the implant that was

determined to not be the result of implant or treatment failure. A second patient was revised at 51 months due to potential edge-loading of the implant against the trochlea, which was determined likely unrelated to the implant. This patient was the subject of a previous AE occurring from 4 to 8 months post-surgery due to "overstretching" of their knee, resulting in an arthroscopic assessment with no known cause of ongoing pain identified.

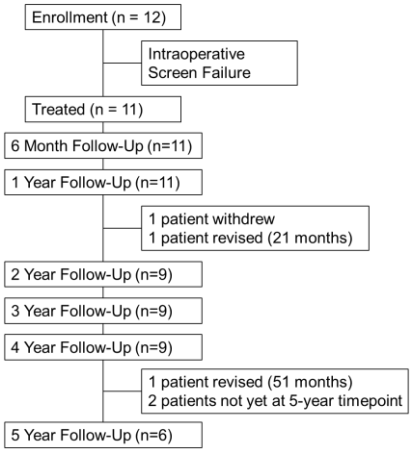

Figure 2: Patient enrollment and follow-up flow chart

Implant Safety

No device-related adverse events were reported. The only events reported were two revisions, an arthroscopic evaluation for one of these revised patients, and a life-threatening unrelated kidney infection at 38 months. This results in a rate of AE occurrence of 27% (n=3/11 patients), and a revision rate of 18% (n=2/11 patients, none were device-related). All events have been resolved by the time of this report.

Given the lack of device-related AEs and the low number of revisions with no revisions that were due to device/treatment failure, the clinical data has provided a clear and positive safety profile.

Results:

The primary endpoint to be measured was a comparison of the main clinical outcome variables (KOOS QoL, Kujala (AKPS), VAS Pain, SF-36, Tegner) between pre-op baseline and 2 years follow up. The secondary endpoint was to continue this comparison to 5 years. The comparisons were made as one-sided, paired t-tests, $\alpha = 0.025$. The results of the study data indicate that the BioPoly Patella device significantly reduced knee pain as measured by KOOS Pain, Kujala, VAS Pain, and SF-36 Pain from 6 months and sustained the improvement for at least 4 years, with many outcomes significant at 5 years and some only trending due to small sample size (**Figure 3b & c**; **Figure 5**). All KOOS scores except Sports/Recreation are statistically improved ($p < 0.025$) up to 5 years, indicating significant improvement in symptoms, pain, activities of daily living, and quality of life (Figure 4). SF-36 outcomes show disparate results, except for SF-36 Pain, as mentioned previously as significantly improved (**Figure 5**). Patients improved their activity as indicated by the significant increase in Tegner Activity Scores (**Figure 3**).

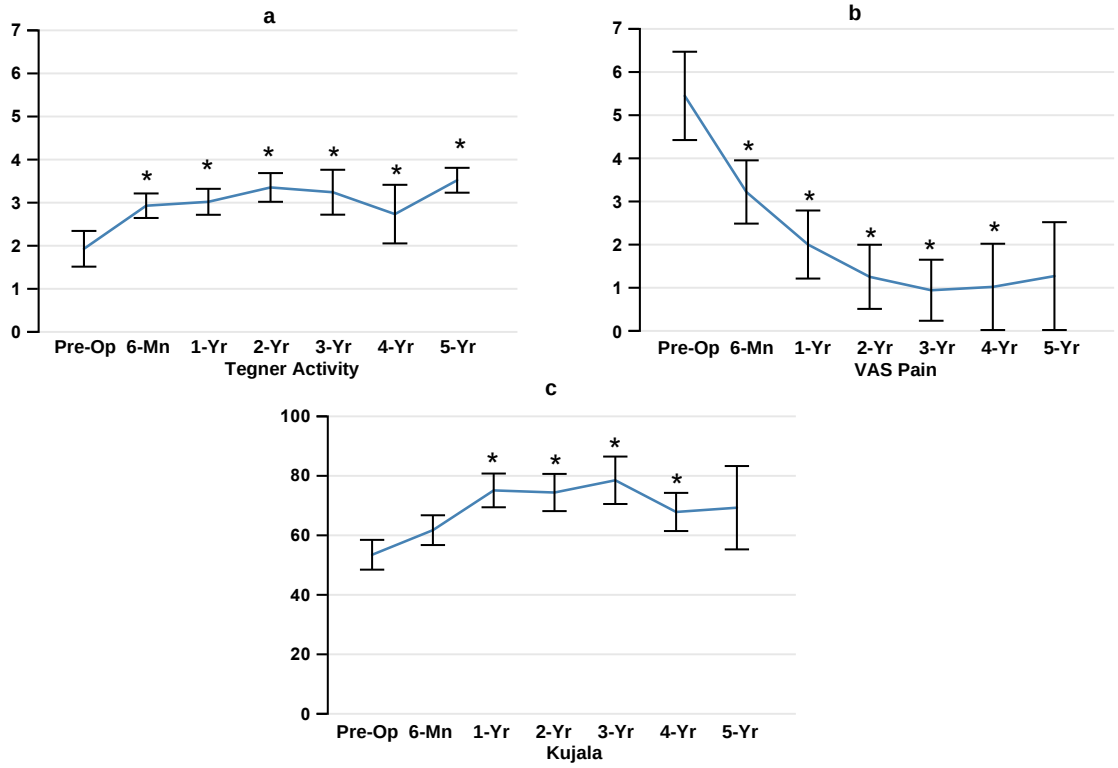

Figure 3: (a) Tegner Activity (b) Visual Analog Scale – Pain and (c) Kujala; Average Std. Error (*p < 0.025 paired improvement from baseline)

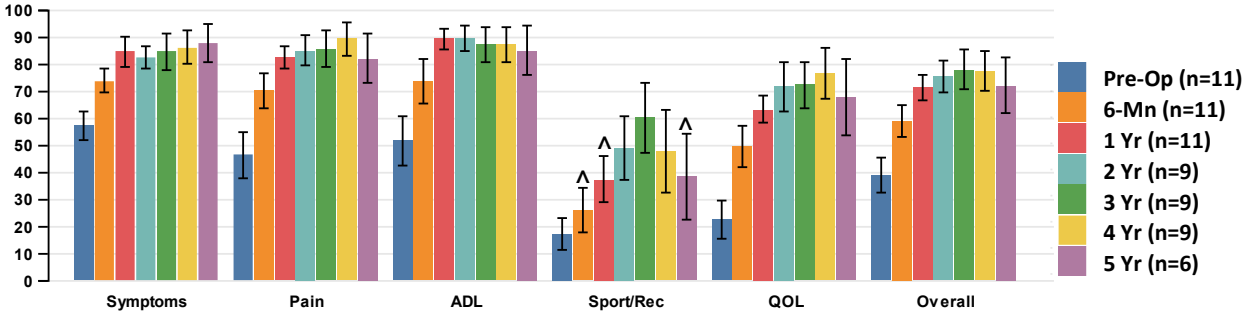

Figure 4: KOOS Data
(<u>All time points</u> significantly improved from baseline, p < 0.025 paired, except as indicated with "^")

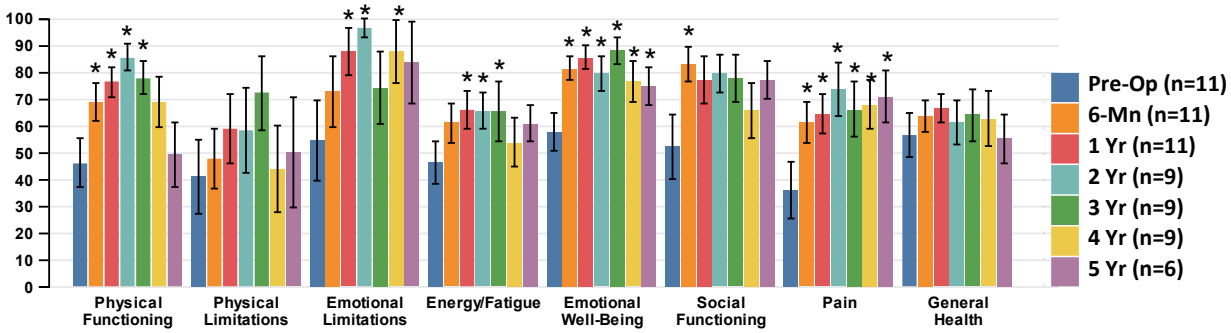

Figure 5: SF-36 Data
(*Significantly improved from baseline, p < 0.025 paired)

Discussion:

The BioPoly Patella implant provides surgeons with a viable option to address their patients' anterior knee pain caused by focal cartilage defects of the patella. In our study, all four pain scoring systems (Kujala, VAS Pain, KOOS Pain, and SF-36 Pain) consistently reported long-lasting and statistically significant reduction in knee pain. With the reduction in knee pain, it followed that patients reported the same or higher levels of activity and improved functional outcomes as was measured by the Tegner Activity Score, Kujala, KOOS and SF36 Physical Functioning. Finally, patients experienced a sustainable and statistical improvement in their overall Quality of Life as was seen in their KOOS QoL scores.

With such consistently positive clinical outcomes that are sustained to 5 years post-surgery, we expect the BioPoly Patella Implant has potential to become the Standard of Care when treating anterior knee pain caused by focal cartilage lesions in the patella.

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Rehabilitation Guidelines

BioPoly RS Partial Resurfacing Patella Implant

	Immediate post-op	*1 – 3 wks*	*4 - 7 wks*	*8 – 11 wks*
Guidelines	Active motion and weight bearing as tolerated.	Weight bearing as tolerated and unrestricted ROM as tolerated.	Weight bearing as tolerated and unrestricted ROM as tolerated.	Return to full activity as tolerated.
Exercises	Passive flexion/extension of knee 500 reps 3 times a day gradually increasing to active flexion/extension.	Active flexion and extension exercises. Stretches for quads, hamstrings and achilles tendon. Quad/hamstring isometrics. Stationary bike with no resistance.	Active strengthening. Elastic resistance cord exercises. Hydrotherapy.	

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