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Long-term results of rib perichondrial grafts for repair of cartilage defects in the human knee

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Summary. *Eighty-eight patients with articular cartilage defects in the knee were treated by perichondrial arthroplasty between 1986 and 1992. An autogenous strip of costal perichondrium was fixed in place with fibrin glue, followed by immobilisation, continuous passive motion, and partial weightbearing. The results were evaluated using the Hospital for Special Surgery Score for knee function, radiographs, arthroscopy and the patient's subjective opinion. The results after a mean follow-up of 52 months were good in 38%, fair in 8% and poor in 55%. Previous drilling or shaving of a defect, concomitant osteoarthritis, older age and a long history of complaints proved to be contraindications. Good results were seen in 91% of isolated defects. Perichondrial arthroplasty can be beneficial in the repair of cartilage defects. It will reduce symptoms in carefully selected cases, and avoid more extensive operations for osteoarthritis.*

Résumé. *Depuis septembre 1986 jusqu'à decembre 1992 quatre-vingt huit patients presentant les lésions cartilagineuses au genou ont été traité par arthroplastie périchondrale. Dans les lésions, une partie du périchondre de la côte a été fixé avec de la colle de fibrine. Les soins consécutifs consistaient à une immobilisation, une mobilisation passive, et a une mise en charge partielle puis complète. L'évaluation des résultats a été fait avec l'aide de la cotation Hospital for Special Surgery pour l'articulations du genou, par examen radiologique, arthroscopie postoperatoire et recueil de l'opinion subjective du patient. Les résultats après une étude moyenne de cinquante deux mois ont été bon à 38%, modéré à 8% et mauvais à 55%. Les contre-indications pour cette technique sont des forages ou nettoyages précédents, l'arthrose, l'âge avancé du patient, et des douleurs préexistantes. Des bons résultats sont vus dans les lésions isolées à 91% (30/33). Nous concluons que l'arthroplastie avec périchondre peut être favorable pour réparer des lésions cartilagineuses. Cette technique peut diminuer les douleurs des patients bien sélectionnés et prévenir les opérations plus compliquées pour arthrose.*

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Introduction

Full thickness defects of articular cartilage have a poor capacity for repair and the current treatment by shaving or drilling produces fibrocartilage whose biomechanical and biochemical qualities are inferior to normal hyaline cartilage, although symptoms may be reduced [15, 27].

Rib perichondrium when transplanted into a cartilage defect produces tissue which closely resembles hyaline cartilage [4, 5, 6, 11, 19], and which may develop into normal hyaline cartilage when placed in a joint [6, 10]. In an animal model, this newly formed cartilage has been shown to have the same visco-elastic properties as hyaline cartilage matched for age and health [32]. Neocartilage with histological and biochemical qualities similar to that of normal articular has been

Table 1. Localisation of articular cartilage defects in 88 patients

	Isolated defect	2 defects
n (patients)	70	18
Follow-up	51 months	56 months
Male	41	10
Female	29	8
Mean age	30 years	36 years
Patella	37	13
Median femoral condyle	28	15
Lateral femoral condyle	2	3
Trochlea	3	5

reported one year after perichondrial grafting in rabbits [1, 3, 20, 27, 28, 29].

A method of graft fixation was described in 1986 using nontoxic, nonallergic and biodegradable glue with initial low, but rapidly increasing, adhesive strength [31]. This was successful in rabbit's knees and in a small mixed group of patients with chondral and coexisting lesions.

The purpose of this paper is to evaluate the long term results of perichondrial grafting in human knees. This is the first clinical study with a follow up of more than 4 years [16].

Patients and methods

From September 1986 to December 1992, 88 patients with articular cartilage defects were treated by perichondrial arthroplasty in the University Hospital, Maastricht [2, 8, 16, 25, 26]. The study was approved by the local ethics committee and was performed in accordance with the ethical standards laid down by the 1994 Declaration of Helsinki. Informed consent was obtained before inclusion in the study.

One hundred and six cartilage lesions were treated in 88 patients, 40 in the right and 48 in the left knee, in 37 women and 51 men. No exclusion criteria were used, except for age (<55 years). An isolated defect was treated in 70 patients; in 18 there were two defects in the same knee. In 13, the perichondrial arthroplasty was combined with an additional procedure, such as anterior cruciate ligament (ACL) repair or a meniscectomy. The mean follow up was 52 months (range 14 to 80 months). The mean age at operation was 31.3 years (range 15 to 54 years).

Most perichondrial grafts were placed in the medial and central areas of the patella, in the intercondylar region of the medial femoral condyle and in the weightbearing area of this condyle (Table 1) [31]. The lesions were traumatic in 31 patients; previous ACL lesions were present in 31, and 12 had osteochondritis dissecans with slight bone loss which had been treated unsuccessfully by drilling. Abnormalities of the menisci were present in 41 patients. In the group of patients with a good Hospital for Special Surgery score (HSSS), 17/33 had grade 1–2 osteoarthritis at arthroscopy. Of those with a poor score, 18/48 had grade 1–2 osteoarthritis [7] and 5 had grade 3–4 changes (Table 4b). The size of the cartilage defects was from 0.3 cm^2 to 20.5 cm^2.

Operative technique

The leg was exsanguinated after general anaesthesia with the patient supine. A medial parapatellar incision was used and the patella dislocated laterally, if necessary. The chondral lesion was cleaned with a sharp instrument until bleeding points were visible in the subchondral bone, allowing a better passage for cells. The surrounding cartilage was cut in order to demarcate the lesion.

An oblique incision was made over the lower part of the left side of the chest, the fascia of the rectus muscle was split transversely and the muscle in the line of its fibres. The perichondrium was removed, including its chondrogenic layer, from one of the lower costal cartilages. The graft was cut to the size of the defect. Two transplants were sometimes needed to cover the entire surface of a large defect. The graft was fixed with fibrin glue (Tissucol^R, Immuno, Vienna) [14]. The perichondrial graft was placed on the subchondral bone with the chondral side facing the joint; it was firmly pressed to the underlying bone with a wet gauze for one minute, and the knee then moved to assess its fixation. The patella was relocated and the wound closed.

After immobilisation for 2 weeks in plaster, continuous passive motion was used for another 2 weeks [23]. Movement was encouraged, but for grafted lesions of the patella and the intercondylar groove flexion was limited to 30°. Four weeks after operation, the patients were allowed up nonweightbearing and active movements encouraged. Full weightbearing was begun 3 months after the operation [17].

After a mean follow up of 52 months (range 14 to 80 months), the results were evaluated by the HSSS, radiographs, a visual analogue scale and arthroscopy one year after the operation. The patients were seen at intervals of 4, 8 and 12 weeks and thereafter at 1½, 2, 3, 4 years and later. No histochemical or biochemical assessment of the repair tissue was undertaken because a biopsy could not be justified on ethical grounds.

We studied the correlations between the success rate and the site of the lesion, the size of the graft, calcification of the graft seen on radiographs, coexisting abnormalities in the knee and combinations of treatment in relation to the HSSS score. A result was rated good if the score was >85 and the arthroscopic appearances were good. Failure was a score of <75 whether the arthroscopy was good or bad, and so was a score >75 in combination with a bad result at arthroscopy or with a need to reoperate. Any loosening of the graft, outgrowth above the surrounding tissue or progressive osteoarthritis seen at arthroscopy were failures. A score of 75–84 was fair.

A second group of 14/88 patients were operated on from 1989 to 1992 using a different technique in which the graft was perforated in order to avoid haematoma formation. This group were also given indomethacin 25 mg 3 times a day from the day before operation for 2 weeks to minimise calcification in the graft. The mean follow-up was 14.5 months (range 6 to 29 months).

Results

In 33/88 (38%) the result was excellent or good; 7 (8%) were fair and 48 (55%) were failures, mainly because of loosening of the graft seen at arthroscopy (Table 2). The fair group have been omitted from the tables for clarity. In the whole group, 27% of the grafts were lost (24/88) (Table 3) and this

Table 2. Results H.S.S.S. (n = 88)

	Points	n	%
Excellent/good	85–100	33	38%
Fair	75–84	7	8%
Poor	<75	10	
Reoperation/arthroscopic failure		38	55%

Table 3. Failures and localisation of the graft (n = 48)

	n	%
Patella	23/37	62%
Medial femoral condyle	10/28	36%
Combined	14/18	78%
Trochlea	1/3	33%

was significantly worse for grafts on the medial femoral condyle (p <0.05, chi-squared test) (Table 4c).

In 10/88 patients (11%), failure was caused by growth of the graft above the surrounding cartilage which felt hard at arthroscopy, and occurred most often when the patella was grafted (7/37).

Progressive osteoarthritis, as seen at arthroscopy one year after operation, occurred in 4/88 patients, and 3 of these had more than one graft. Isolated patellar grafts failed in 23/37, and so did 10/28 of the medial femoral condyle grafts (Table 3). The highest rate of failure (14/18) was in double perichondrial grafts.

Radiographs showed calcification within the graft one or 2 months after operation. Excluding the arthroscopic failures and those that were operated on again, calcification was seen in 25/47; in 22 there was no calcification (Table 5).

Instability and previous meniscectomy were not detrimental to the clinical results (Table 4a).

Previous drilling or shaving of the defect, age above 40 years and a long period of complaints before operation influenced the results adversely (Table 4a, b). When more than one graft was used, the results were poor (P <0.05). Osteoarthritis above grade 2 (fibrillation) in other parts of the knee at arthroscopy proved an absolute contra-indication for grafting (Table 4b). Seven patients (7/12) with osteochondritis dissecans with only slight bone loss had good results. The size of the lesion had an adverse effect, but this was not significant; in 48 with a poor result, the average size of the lesion was 3.97 cm^2, compared with 3.17 cm^2 in 33 who had a good result.

The 14/88 patients given indomethacin for prophylaxis had a reduced incidence of calcification in the graft, their mean follow up was

Table 4a. Results of perichondrial arthroplasty

	Good		Poor		Sig.
	n = 33		n = 48		
1 graft	30	91%	34	71%	*
2 grafts	3	9%	14	29%	*
Surface cm^2	3.17	0.4–20.5	3.97	0.8–15	N.S.
Duration of complaints (months)	40.2	1–120	52.5	5–240	N.S.
Age at operation (years)	28	17–41	32.6	15–48	#

* = P <0.05 # = P <0.025

Table 4b. Results of perichondrial arthroplasty in relation to the cause of the defect in 88 patients

	Good	Poor	
	n = 33	n = 48	Sig.
Trauma	15	15	N.S.
Osteochondritis dissecans	7	4	N.S.
Previous debridement	9	22	N.S.
Osteo-arthritis			
Gr 0	16	25	N.S.
Gr 1–2	17	18	N.S.
Gr 3–4	0	5	N.S.

P <0.05 significant

Table 4c. Results of isolated defects in the patella and medial femoral condyle

	Good	Poor
Patella	12	23
Medial femoral condyle	15	10

P <0.05

Table 5. Effects of indomethacin (indo) on calcification (calc)

	+ calc	– calc
+ indo	2	10
– indo	23	12

P <0.005

14.5 months (range 6 to 29 months). Two patients in this group were lost and excluded; 2/12 showed calcification. Of 25 calcified grafts, 23 had not receive indomethacin (Table 5). These differences were statistically significant (P <0.005, using chi-squared test with the Yates correction).

Discussion

Chondral lesions in the knee interfere with work and sport, and predispose to osteoarthritis [13]. Spontaneous healing is poor, and shaving and drilling the lesions result in fibrocartilage which is mechanically inferior to articular cartilage.

Rib perichondrium has the potential to differentiate into cartilage with similar properties to hyaline cartilage [2, 3, 6, 10]. Our study shows that the success of this procedure depends on the selection of patients. Contraindications to the procedure are more than one defect, previous debridement operations, a long history of symptoms, age over 40 years, and grade 2 or worse osteoarthritis in the rest of knee. Grafting the patella was less successful because of the mechanical demands and pressure in this area. Good or excellent results were seen with an isolated traumatic defect of the medical femoral condyle in patients under 40 years.

Fibrin provides sufficient immediate fixation [22], but we used immobilisation to ensure that this fixation was not disturbed [14]. Continuous passive motion was used because of its beneficial effect on cartilage regeneration [23]. During the first 3 months weightbearing was not allowed because the superficial part of the graft was assumed to be soft. Movement was limited to 30° for patellar grafts, but otherwise was encouraged.

The calcification seen in radiographs may be due to mineralisation of the base of newly formed cartilage which could have an adverse effect on the visco-elastic properties of the new cartilage and its durability [22]. We considered this increased mineralisation was a cause of loosening and the raised hard surface which was found in some of our cases. Indomethacin was shown to prevent calcification and its use should improve the results. Perforating the graft reduces the risk of loosening by preventing haematoma formation.

The design of this study allowed us to establish the indications for perichondrial grafting in the knee. The best results are in patients under 40 years with isolated defects, and without osteoarthritis elsewhere in the joint. We are undertaking further work to improve fixation and prevent calcification.

References

1. Aaron JE (1980) Alkaline phosphatase, vesicles and calcification. Metab Bone Dis Rel Res 2: 151–157
2. Amiel D, Coutts RD, Abel M, Stewart W, Harwood F, Akeson WH (1985) Rib perichondrial grafts for the repair of full-thickness articular-cartilage defects. J Bone Joint Surg [Am] 67: 911–920
3. Amiel D, Coutts RD, Harwood FL, Ishizue KK, Kleiner JB (1988) The chondrogenesis of rib perichondrial grafts for repair of full thickness articular cartilage defects in a rabbit model: a one year postoperative assessment. Connect Tissue Res 18: 27–39
4. Billings E, Schroeder von HP, Mai MT, Aratow M, Amiel D, Woo SL-Y, Coutts RD (1990) Cartilage resurfacing of the rabbit knee. Acta Orthop Scand 61: 201–206
5. Coutts RD, Amiel D, Woo SL-Y, Woo Y-K, Akeson WH (1984) Technical aspects of perichondrial grafting in the rabbit. Eur Surg Res 16: 322–328
6. Coutts RD, Woo SL-Y, Amiel D, Schroeder von HP, Kwan MK (1992) Rib periochondrial autografts in full-thickness articular cartilage defects in rabbits. Clin Orthop Rel Res 275: 263–273
7. Dandy DJ, Jackson RW (1975) Meniscectomy and chondromalacia of the femoral condyle. J Bone Joint Surg [Br] 57: 1116–1119
8. Engkvist O, Ohlsén L (1979) Reconstruction of articular cartilage with free autologous perichondrial grafts. Scand J Plast Reconstr Surg 13: 269–274
9. Engkvist O, Skoog V, Pastacaldi P, Yormuk E, Juhlin R (1979) The cartilaginous potential of the perichondrium in rabbit ear and rib. Scand J Plast Reconstr Surg 13: 275–280
10. Engkvist O (1979) Reconstruction of patellar articular cartilage with free autologous perichondrial grafts. Scand J Plast Reconstr Surg 13: 361–369
11. Enkvist O, Wilander E (1979) Formation of cartilage from rib perichondrium grafted to an articular defect in the femur condyle of the rabbit. Scand J Plast Reconstr Surg 13: 371–376
12. Engkvist O, Johansson SH (1980) Perichondrial arthroplasty. Scand J Plast Reconstr Surg 14: 71–87
13. Ficat P, Ficat C, Gedeon P (1978) Posttraumatic arthrosis and postcontusive chondrosis. Rev Chir Orthop Reparatrice Appar Mot 64: 19–34
14. Gibble JW, Ness PM (1990) Fibrin glue: the perfect operative sealant? Transfusion 30: 741–747
15. Haynes DW (1980) The mineralization front of articular cartilage. Metab Bone Dis Rel Res 2: 55–59
16. Homminga GN, Bulstra SK, Bouwmeester SJM, Linden van der AJ (1990) Perichondrial grafting for cartilage lesions of the knee. J Bone Joint Surg [Br] 72: 1003–1007
17. Kon M (1981) Cartilage Formation from perichondrium in a weightbearing joint. Eur Surg Res 13: 387–396
18. Kwan MK, Coutts RD, Woo SL-Y, Field FP (1989) Morphological and biochemical evaluations of neocartilage from the repair of full-thickness articular cartilage defects using rib perichondrium autografts: a long term study. J Biomechanics 22: 921–930
19. Maruyama Y (1979) An experimental study on cartilage formation in autogenous perichondrial transplantation in rabbits. Keio J Med 28: 63–72
20. Ohlsén L (1978) Cartilage regeneration from perichondrium. Plast Reconstr Surg 62: 507–513
21. Ohlsén L, Widenfalk B (1983) The early development of articular cartilage after perichondrial grafting. Scand J Plast Reconstr Surg 17: 163–177
22. Passl R, Plenk H Jr (1989) Fibrin adhesion of cartilage surfaces. Beitr Orthop Traumatol 36: 503–507
23. Salter RB, Simmonds DF, Malcolm BW, Rumble EJ, Macmichael D, Clements ND (1980) The biological effect of continuous passive motion on the healing of full-thickness defects in articular cartilage. J Bone Joint Surg [Am] 62: 1232–1251
24. Seradge H, Kutz JA, Kleinert HE, Lister GD, Wolff TW, Atasoy E (1984) Perichondrial resurfacing arthroplasty in the hand. J Hand Surg Am 9: 880–886
25. Skoog T, Ohlsén L, Sohn SA (1972) Perichondrial potential for cartilagenous regeneration. Scand J Plast Reconstr Surg 6: 123–125
26. Skoog T, Ohlsén L, Sohn SA (1975) The chondrogenic potential of the perichondrium. Chir Plastica (Berl) 3: 91–103

27. Solursh M (1991) Formation of cartilage tissue in vitro. J Cellular Biochem 45: 258–260
28. Upton J, Sohn SA, Glowacki J (1981) Neocartilage derived from transplanted perichondrium: what is it? Plast Reconstr Surg 68: 166–172
29. Wasteson Å, Ohlsén L (1977) Biosynthesis of chondroitin sulphate in cartilage regenerated from perichondrium. Scand J Plast Reconstr Surg 11: 17–22
30. Widenfalk B, Engkvist O, Ohlsén L, Segerstrom K (1986) Perichondrial arthroplasty using fibrin glue and early mobilization. An experimental study. Scand J Plast Reconstr Surg 20: 251–258
31. Widenfalk B, Ekenstam af F (1990) Perichondrial grafting for total replacement of the patella. Scand J Plast Reconstr Hand Surg 24: 97–99
32. Woo SL, Kwan MK, Lee TQ, Field FP, Kleiner JB, Coutts RD (1987) Perichondrial autograft for articular cartilage. Shear modulus of neocartilage studied in rabbits. Acta Orthop Scand 58: 510–515