

Artificial Disc Replacement

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– Abstract –

The current two most popular spine surgeries, discectomy and fusion, at best address the pathology of low back pain, but significantly change the normal structure and function of the disc and lead to further degeneration of the adjacent segments.

Artificial disc replacement (ADR) is considered an alternative to fusion in treatment of the degenerative disc disease. It can restore the normal kinematic and load-shearing properties of diseased lumbar segments, maintaining stability and mobility with relief of pain.

Over the past 40 years, a tremendous effort has been made to develop an artificial disc to replace the degenerated disc. Design criteria of artificial disc include endurance, biocompatibility, galvanic corrosion, geometry, constraints, dynamics, implant stability, and fail-safe.

The indications of ADR are still not clear. But the principal indications include mono- and bi-segmental instability, the post-nucleotomy syndrome, and spondylolisthesis up to Meyerding I after unsuccessful conservative treatment. The contra-indications are osteoporosis, previous or latent local infection, spondylolisthesis greater than Meyerding I, spinal stenosis, as well as degenerative spondylosis, mainly involving facet joints.

There have been several reports about clinical results of ADR. The initial results seem to be good, but follow-up is too short for definite conclusions. Accurate patient selection is imperative to obtain good clinical results. Prospective and longer term studies are needed to evaluate the efficacy of ADR.

The further development in designs and materials of artificial disc is the most important to duplicate not only the natural form of disc but also its function.

Key Word : Artificial disc replacement

80%가

가 가 ,

2).

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polyurethane

(discectomy) 3~5

(segmental instability) 30% (fusion)

1984 modular type SB Charité (Walde-
mar Link GmbH & Co, Hamburg, Germany) Büttner-Jan-
Schellnack

가 (low-fric-
tion) Cr-Co-Mo 2
(cover plate) 1 (UHMW
polyethylene) (sliding core)

1989 Büttner-Jan³⁾ 1991 Zippel⁴³⁾ SB Charité
가
(failure) (subsidence)
(SB Charité I II III).

1993 Enker 2 titanium (end plate) 1
polyolefin rubber core Acroflex
(Acromed corp., Cleveland, OH) 6 3
4 2
replacement) rubber core , rubber core가
(carcinogen) ¹⁰⁾

가

Enker ¹⁰⁾ 가
(endurance), (biocompatibil-
ity), (galvanic corrosion), (geometry),
constraints, (dynamics), implant (stability)
(fail-safe)

1967 Charnley Fernström

1956 van Steenbrughe³⁶⁾가
(migration)

가 1966 Fernström¹²⁾
100
(nucleus pulposus) (substitute)
steel ball (long-term fixation)
(stress) (bone ingrowth)
(migration) 4~7
12%
¹³⁾ 1974 Hoffman-Daimler
(synthetic material) 가
¹⁸⁾ 가 8,11,32), 1977 Schulman 83
2 mm

(stiffness) , roach) (invasive)
(tension) ,
(nucleus substitute)
(failure load) ,
가
(failure strength) 8kN , (pressure modulation)
(shear)
2kN 3kN 9).
(lateral flexion) 1).
working dis-
tance가 가 가
metal ball bearing, silicone fluid
plastic tube silicone rubber nucleus가 23). 1978
Fassio Ginestie¹¹⁾가 silicone
, 1994 Hou 30 silicone
fibrosus)
(annulus)
1991 Lee 23)
4가
1) low friction sliding surfaces, like ball & socket
2) spring & hinge systems 65~93% 19,21,30,35,38)
3) contained fluid-filled chambers
4) discs of rubber or other elastomers (kinematics) (curative)
(material) (palliative)
(polymer) (elastomer) 가 8~10
(fatigue strength) 가 22),
(modulus of elasticity) 가 ness) 가 (stiff-
(interface) 5~7
(polymer)- 가 33
Lehmann 25) 가
(flexibility) 1). 44%가
가 가 , 15%가 , 5%가
SB Charité 42%가
(surgical app- 15%

, 45%

(routine procedure)

. David⁷⁾

,
가

가

tive)

(double-blinded)

가

(prospec-

가 가
가 , kinematic

24,25,37,43)

가 ,

4,7,10)

1)

가 . Hedman¹⁷⁾

가

;

(pseudoradicular symptom)

가 .

2)

(post-nucleotomy syndrome);

(pos-

가 ,
(distraction)

가

terior element)가

3) 55

Grade I

4)

가 ,

가 가

가

(subchondral bone)

가

polyethylene (wear)

7).

7).

(posterior element)

가

6,20)

. Nachemson²⁹⁾
psychosocial

가

. Frymoyer¹⁴⁾ Nachemson²⁹⁾

가

5%

Frymoyer¹⁴⁾

(discography)

(bone densitometry)

cost-effective 가

4,7,10)

1)

2)		McKenzie ²⁸⁾	103	155	steel ball
		79%			
3) Grade II		steel ball			
4)				가	
5)	(facet joint)	가			SB Charité
		가			(Waldemar Link GmbH & Co, Hamburg, Germany)
Scheuermann		1988 Büttner-Jan	4) 62	76	
		83%			
			, 1991 Zippel ⁴³⁾	55%	
		, 29%			. 1989 Wittig ⁴¹⁾
		3~18	77%		
		. 1993 David ⁷⁾	22	29	
		1	65%		
				(loosening)	
		(osteolysis)가		(segment mobility)	
		1994 Griffith ¹⁵⁾		가	multicen-
		ter (retrospective)		. 93	139
				가	
incision)		가			
		(pararectal			
		7).	가		(failure), (migra-
			(dislocation)가	6.5%	가
		‘ H ’			
spreader					
		1996 Cinotti ⁵⁾	46	56	
		2	63%		
				7	
				(failure),	(osteoly-
		2 mm	sis)가		10
			가		
(fluoroscope)					
				80%	
1993 Enker ¹⁰⁾	Acroflex	(Acromed			
corp., Cleveland, OH)	6	3		(subsidence)	
4		rubber core			
가					
1966 Fernström ¹²⁾	stainless steel ball	40%	1997 Lemaire ²⁶⁾	105	
		51	79%		
		, 1995	87%		

가 (malposition)

가 (subsidence)

1999 Zeegers⁴²⁾ 50
2 70%

가

13%,
4%

, 45

Büttner-Jan⁴⁾

Cinotti⁵⁾

2 43%

Griffith¹⁵⁾

kinematic

(efficacy)

(survival) 가

가

Griffith

가¹⁵⁾

1)
(breakage), (fissure), (deformation)

2)
(migration), (dislocation)

3)
; (phlebitis),
(dehiscence),
(incontinence),
(retrograde ejaculation), (reflex
sympathetic dystrophy), (nausea),
4) 가

Griffith

¹⁵⁾ 6.5%, Lemaire²⁶⁾ 2.9%, Zeegers⁴²⁾ 4%

(exposure)

⁵⁾ (surgical trauma)

(ingrowth)
(metaplasia)¹⁰⁾

REFERENCES

- 1) Bao QB, McCullen GM, Higham PA, Dumbleton JH and Yuan HA : *The artificial disc: theory, design and materials. Biomaterials*, 17:1157-1167, 1996.
- 2) Büttner-Jan⁴⁾, K, Schellnack, K and Zippel, H : *An alter - native therapeutic strategy using the disk endoprosthesis of the SB Charité modular type in lumbar disc lesions. Z. Orthop*, 125:1-6, 1987.
- 3) Büttner-Jan⁴⁾, K, Schellnack, K and Zippel, H : *Biome - chanics of the SB Charité lumbar intervertebral disc endo - prothesis. Int Orthop*, 13:173-176, 1989.
- 4) Büttner-Jan⁴⁾, K, Schellnack, K, Zippel, H and Conrad P : *Experience and results with the SB Charité lumbar inter - vertebral endoprosthesis. Z. Klin*, 43(20):1785-1789, 1988.
- 5) Cinotti G, David T and Postacchini F : *Results of disc prothesis after a minimum follow-up period of 2 years. Spine*, 21:995-1000, 1996.
- 6) Cyron BW and Hutton WC : *Articular tropism and sta -*

- bility of the lumbar spine. *Spine*, 5:168-172, 1980.
- 7) **David T** : Surgical technique, indications and clinical results in 22 patients with a minimum of 12 months follow-up. *Eur Spine*, 1:254-259, 1993.
- 8) **Edelard, H.G** : Plan logique d'une prothese du disque intervertebral. Conditions biomecaniques et biomateriaux requis. *Acta Orthop Belg*, 47:130-134, 1981.
- 9) **Eijkelkamp MF, Donkelaar VCC, Veldhuizen AG, Horn VJR, Huyghe JM and Verkerke CJ** : Requirements for an artificial intervertebral disc. *The Int J Artif Organs*, 24:311-321, 2001.
- 10) **Enker P, FRCS, Steffee A, Mcmillin C, Keppler L, Biscup R and Miller S** : Artificial Disc Replacement. *Spine*, 18:1061-1070, 1993.
- 11) **Fassio B and Ginestie JF** : Prothese discale en silicone. Etude experientale et premieres observations cliniques. *Nouv Presse Med*, 21:207, 1978.
- 12) **Fernström U** : Arthroplasty with intercorporal endoprosthesis in herniated disc an in painful disc. *Acta Chir Scand Suppl*, 357:154-159, 1966.
- 13) **Fernström U** : Arthroplasty with intercorporalendoprosthesis in herniated and painful disc. *Acta Chir Scand*, 4:165-186, 1973.
- 14) **Frymoyer JW** : Indications for consideration of the artificial disc (in Weinstein JN ed. *Clinical efficacy and outcome in the diagnosis and treatment of low back pain*. New York, Raven Press, 227-236, 1992).
- 15) **Griffith SL, Shelokov AP, B ttner-Janzen K, LeMaire JP and Zeegers WS** : Multicentric retrospective study of the clinical result of Link® SB Charité intervertebral prosthesis. The initial European experience. *Spine*, 19:1842-1849, 1994.
- 16) **Harms J and Hess H** : Indikation, operative problematik und Ergebnisse der Renukleotomie. *Z. Orthop*, 112:824-825, 1974.
- 17) **Hedman TP, Kostuik JP, Femie GR and Hellier WG** : Design of an intervertebral disc prosthesis. *Spine*, 16:256-260, 1991.
- 18) **Hoffmann-Daimler S** : Zur Frage des Bandscheibenersatzes. *Z Orthop*, 112:792-795, 1974.
- 19) **Jackson RK, Boston DA and Edge AJ** : Lateral mass fusion. A prospective study of a consecutive series with long term follow up. *Spine*, 10:828-832, 1985.
- 20) **King AI, Prasad P and Ewing CL** : Mechanism of spinal injury due to cephalocaudal acceleration. *Orthop Clin North Am*, 6:19-31, 1975.
- 21) **Kiviluoto O, Santavirta S, Salenious P, Morri P and Pylkkannen p** : Posterolateral spine fusion. A 1-4 year follow up of 80 consecutive patients. *Acta Orthop Scand*, 56:152-154, 1985.
- 22) **Lee CK** : Accelerated degeneration of the segment adjacent to a lumbar fusion. *Spine*, 13:375-377, 1988.
- 23) **Lee CK, Langrana NA, Parsons JR and Zimmerman MC** : Development of a prosthetic intervertebral disc. *Spine*, 16:253-260, 1991.
- 24) **Lee CK, Parsons JR, Langrana NA and Zimmerman MC** : Scientific basis: relative efficacy of the artificial disc versus spinal fusion (in Weinstein JN ed. *Clinical efficacy and outcome in the diagnosis and treatment of low back pain*. New York, Raven Press, 237-244, 1992).
- 25) **Lehmann TR, Spratt KF and Tozzi JE** : Long-term follow-up of lower lumbar fusion patients. *Spine*, 12:97-104, 1987.
- 26) **Lemaire JP, Skalli W, Lavaste F, Templier A, Mendes F, Diop A, Sauty V and Laloux E** : Intervertebral disc prosthesis. *Clin Orthop*, 337:64-76, 1997.
- 27) **Matsunaga S, Skou T, Taketomi E and Nakanisi K** : Effects of strain distribution in the intervertebral discs on the progression of ossification of the posterior longitudinal ligaments. *Spine* 21:184-189, 1996.
- 28) **McKenzie AH** : Fernström intervertebral disc arthroplasty: a long term evaluation. *Orth Int ed*, 3(4):313-324, 1995.
- 29) **Nachemson AL** : Challenge of the artificial disc(in Weinstein JN ed. *Clinical efficacy and outcome in the diagnosis and treatment of low back pain*. New York, Raven Press, 271-278, 1992).
- 30) **O'Beirne J, O'Neill D and Williams DH** : Spinal fusion for back pain: A clinical and radiological review. *J Spinal Discord*, 5:32-38, 1992.
- 31) **Schmitt O, Fritsch E, Hassinger M and Schnitt E** : Epikritische Langzeitergebnisstudie nach lumbaler Bandscheibenoperation aus den Jahren .1965-1979. *Z. Orthop*. 121-393, 1983.
- 32) **Schneider, PG and Oyen R** : Plastische Bandscheibenchirurgie. I. Mitteilung:Bandscheibenersatz im lumbalen Bereich mit Silikonkautschuk. Theoretische und experimentelle Untersuchungen. *Z. Orthop*, 112:1078-1086, 1974.
- 33) **Schuler P, Clemns D and Rossak K** : Nachuntersuchungsergebnisse nach lumbalen Renukleotomien. *Z. Orthop*, 121:33-36, 1983.
- 34) **Schulman CM** : Metod kombinirowannogo chirurgicheskogo letschenija kompressionnykh form pojasnitschnogo osteochondrosa a alloprotesirowaniem porashennykh

- meshposwonkowych diskow. Vop Neurokhr, 2:17-23, 1977.*
- 35) **Stauffer RN and Coventry MB** : Posterolateral lumbar spine fusion. Analysis of Mayo Clinic series. *J Bone and Joint Surg [AM]*, 1195-1204, 1972.
 - 36) **Steenbrugghe VMH** : Perfectionnements auxéprothésis articulaires [Improvements in articular prostheses] *FR-PS 1.122.634-28.5.56.*
 - 37) **Steffee A** : Artificial disc. Elastomer core between flat rigid plate. *US Patent No 5071437, 1991.*
 - 38) **Suzuki T, Percy MJ, Tibrewal SB, Wilson D and Duthie RB** : Posterior intertransverse fusion assessed clinically and with biplanar radiography. *Int Orthop*, 9:11-17, 1985.
 - 39) **Walker N and Kehr P** : Discushernien-operationen. Langzeitverläufe nach lumbaler Diskushernien-Operation. *Orthopäde*, 8:211-214, 1979.
 - 40) **Wittig C and Müller RT** : Erste Erfahrungen mit der Bandscheibenprothese SB Charité. *Klinikerzt* 17:712-720, 1983.
 - 41) **Wittig C, Müller RT, Staudte HW and Behrens K** : Bandscheibenprothese SB Charité, Erfolge und Mißerfolge an hand von Frühergebnisse. *Med Orthop Technik* 109:70-74, 1989.
 - 42) **Zeegers WS, Bohnen LMLJ, Laaper M and Verhaegen MJA** : Arthricial disc replacement with the modular type SB Charité III: 2-year results in 50 prospectively studied patients. *Eur Spine*, 8:210-217, 1999.
 - 43) **Zippel H** : "Charité Modular": Conception, Experience and Results(in Brook m, Mayer HM, Weigel K eds. *The artificial disc. Springer-Verlag*, 69-78, 1991).