College voor zorgverzekeringen

Onderwerp:	**Percutane transforaminale endoscopische discectomie bij lumbale hernia is niet conform de stand van wetensdchap en praktijk**
Samenvatting:	Op 10 oktober 2006 heeft het CVZ advies uitgebracht omtrent de lumbale hernia-operatie volgens de PTED-methode. De conclusie van het CVZ luidde dat deze methode niet conform de stand van de wetenschap en praktijk was en daardoor niet onder de te verzekeren prestaties viel. Naar aanleiding van vragen hierover uit het veld heeft het CVZ onderzoek laten verrichten naar de PTED-methode voor o.a. de lumbale hernia. Met de resultaten van dit onderzoek hebben de desbetreffende wetenschappelijke verenigingen ingestemd. De resultaten van het onderzoek bevestigen het standpunt dat de PTED-methode bij een lumbale hernia niet voldoet aan de stand van de wetenschap en praktijk. De lumbale hernia-operatie volgens de PTED-mehode valt niet onder de te verzekeren prestaties.
Soort uitspraak:	SpZ = standpunt Zvw
Datum:	10 juli 2008

Onderstaand de volledige uitspraak.

Inleiding

Aanleiding

Hernia nuclei pulposi

Er bestaan diverse behandelingsmogelijkheden voor lumbale hernia nuclei pulposi (HNP). Aanvankelijk verdient conservatief beleid de voorkeur. Bij langer aanhouden van klachten, onhoudbare pijn en enkele andere indicaties is operatief ingrijpen de behandeling van eerste keus. Open chirurgie is de gouden standaard, echter er is groeiende belangstelling voor minimaal invasieve technieken.

Beoordeling endoscopische hernia-operatie in 2002

In 2002 heeft het CVZ de endoscopische hernia-operatie als gebruikelijk in de kring der beroepsgenoten aangemerkt.[1] Voor die beoordeling is naar de op dat moment gepubliceerde wetenschappelijke literatuur gekeken, echter er is mede door de verwarrende terminologie op dit terrein, niet gedifferentieerd tussen de verschillende gebruikte technieken: er is geen onderscheid gemaakt tussen de micro-endosopische techniek, de posterolaterale benadering of de transforaminale benadering. Ook was op dat moment de werkwijze bij de beoordeling van 'gebruikelijkheid' van zorg nog niet

uitontwikkeld.

Introductie Zorgverzekerings-wet en criterium 'stand van de wetenschap en praktijk'

Sindsdien is de Zorgverzekeringswet in werking getreden (per 1 jan 2006) waarin, ter vervanging van het begrip 'gebruikelijkheid' in de Ziekenfondswet, het criterium 'stand van de wetenschap en praktijk' is geïntroduceerd. Het CVZ heeft bij het bepalen of zorg aan dit criterium voldoet een werkwijze ontwikkeld die de principes van evidence based medicine volgt.[2] Nadat de beschikbare wetenschappelijke literatuur volgens deze werkwijze is geordend en geclassificeerd vindt besluitvorming plaats. Uitgangspunt hierbij is dat er minstens één studie van A1 niveau (systematische review) of minstens twee studies van A2 niveau (randomized controlled trial) beschikbaar dienen te zijn om een ondubbelzinnige beslissing te kunnen nemen. Als dergelijke studies niet aanwezig zijn betrekt het CVZ evidence van een lagere orde, maar dient ook beargumenteerd te worden waarom er geen evidence van een hoger niveau beschikbaar is of zal komen. Met andere woorden: op grond van lagere evidence kán een positieve beslissing worden genomen m.b.t. de stand van de wetenschap en praktijk, maar dit moet met steekhoudende argumenten omkleed zijn. Voorbeelden van dergelijke argumenten zijn medisch-ethische bezwaren tegen randomisatie of brede consensus in de beroepsgroepen over de zorgvorm in kwestie.

Beoordeling PTED in 2006

Volgens deze werkwijze heeft het CVZ in 2006 de percutane transforaminale endoscopische discectomie (PTED) beoordeeld. Deze interventie is beoordeeld als niet conform de 'stand van de wetenschap en praktijk'.[3] Dit standpunt heeft veel discussie opgeroepen. De beroepsgroep in Nederland kan zich weliswaar in grote lijnen in dit standpunt vinden: de ingreep wordt in de reguliere ziekenhuizen niet of nauwelijks uitgevoerd. In enkele ZBC's echter, in binnen- en buitenland, vindt deze ingreep wel plaats, maar wordt na publicatie van het standpunt in 2006 niet meer vergoed. Vanwege deze discussie heeft het CVZ besloten om een systematische review te laten verrichten naar de 'stand van de wetenschap en praktijk' van de PTED bij de indicatie lumbale HNP. Omdat gebleken is dat de transforaminale techniek ook bij de diagnose 'wervelkanaalstenose' wel wordt toegepast is ook deze indicatie d.m.v. een systematische review in kaart gebracht; deze wordt in een afzonderlijk rapport besproken.

Aandachtspunten

Voor een goed inzicht in deze discussie is voorts het volgende van belang:

- betr. beroepsgroepen (neurochirurgen, orthopeden) zijn i.h.a. terughoudend met operatief ingrijpen bij een lumbale HNP, conform de geldende richtlijn (update in conceptvorm beschikbaar),[4] en conform recent gepubliceerde (Nederlandse) studies. Er is immers uit wetenschappelijk onderzoek gebleken dat met een

afwachtende houding en adequate pijnstilling de klachten van een HNP in het merendeel van de gevallen spontaan verdwijnen.
- Dit kan voor patiënten een onbevredigende situatie opleveren: men heeft pijn en 'er wordt niets gedaan'.
- Minimaal invasieve chirurgie verlaagt de drempel tot het doen van een operatieve ingreep: er is vaak geen narcose of opname in het ziekenhuis nodig.
- ZBC's springen hierop in door het aanbieden van minimaal invasieve operaties. Patiënten die in Nederland niet voor een ingreep in aanmerking komen, wijken uit naar bv. Duitsland, waar zij wel worden geopereerd.

Vanuit de pakketbeheerdersvisie kan dit leiden tot niet-rationeel en ondoelmatig gebruik van collectieve middelen: de interventie voldoet –wellicht- niet aan het criterium stand van de wetenschap en praktijk (= niet rationeel) en er is niet altijd een goede indicatie voor operatief ingrijpen (= niet doelmatig).

Achtergrond: behandeling van lumbale hernia nuclei pulposi

Hernia nuclei pulposi

De hernia nuclei pulposi (HNP) van de lumbale wervelkolom is een uitstulping van een discus intervertebralis. Door druk van de hernia op de uittredende zenuw kan zenuwpijn met uitstraling in het been ontstaan. In de CBO-richtlijn waarvan de update op dit moment in concept voorligt, wordt gesproken van een lumbosacraal radiculair syndroom (LRS). Dit wordt gedefinieerd als in de bil en/of het been uitstralende pijn, vergezeld van één of meerdere symptomen of verschijnselen die suggestief zijn voor een aandoening van een specifieke lumbosacrale zenuwwortel. In het merendeel van de gevallen wordt dit door een HNP veroorzaakt, soms zijn andere oorzaken aan te wijzen, of is de oorzaak niet duidelijk.

Incidentie in Nederland

In de huisartsenpraktijk is de incidentie van het LRS 9/1000 patiënten per jaar.[4] Bij het merendeel van de patiënten (80%) verdwijnen de klachten na verloop van tijd met een conservatief beleid.[5] Dit beleid bestaat uit goede pijnstilling en activiteiten naar vermogen. Als de pijnklachten aanhouden verschuift de balans naar chirurgisch ingrijpen. De periode van afwachten is internationaal nogal verschillend: in de VS en in Nederland wordt relatief snel geopereerd, in Engeland wordt vrij lang (6 maanden) gewacht. In het verleden werd in Nederland geadviseerd gedurende een periode van zes weken af te wachten, echter n.a.v. recent onderzoek (o.a. Peul et al[6]) wordt in de nieuwe conceptrichtlijn een periode van minstens drie maanden genoemd. Dit wordt overigens uiterst genuanceerd weergegeven: "een tendens naar een in opzet conservatieve behandeling verdient in de eerste drie maanden de voorkeur, terwijl in de daarop volgende drie maanden de tendens steeds sterker naar operatie zal zijn bij aanhoudende

Conservatief beleid

Operatief ingrijpen of toenemende pijnklachten." De winst van chirurgie ligt vooral in de korte termijn, namelijk snellere pijnreductie.
Indien gekozen wordt voor operatief ingrijpen is de gouden standaard de open, (micro-)chirurgische discectomie.[4-8] Hiernaast zijn endoscopische technieken in opkomst, waarbij de benadering posterolateraal/transflavaal (bv. micro-endoscopische discectomie, MED) of transforaminaal (percutane transforaminale endoscopische discectomie, PTED) kan zijn. Op dit moment loopt in Nederland een multicenter RCT waarin MED wordt vergeleken met microchirurgie.[8] Resultaten worden in 2009 verwacht.

Standaard behandeling Indien chirurgische behandeling voor een HNP is aangewezen is de open microchirurgische techniek de standaard-behandeling. Een zorgvuldige indicatiestelling is vereist: in het merendeel van de gevallen verbeteren de klachten bij een conservatief beleid.

Nieuwe interventie De PTED behandeling wordt onder plaatselijke verdoving en in dagbehandeling uitgevoerd. De hernia wordt geattaqueerd via het foramen intervertebralis, het kanaal waardoor de zenuwbundel uittreedt. Er wordt gewerkt via een endoscoop.

Literatuuronderzoek percutane transforaminale endoscopische discectomie bij hernia nuclei pulposi

Vraagstelling

Er is een systematische literatuurreview uitgevoerd met als vraagstelling 1) de effectiviteit van transforaminale endoscopische chirurgie; en 2) de effectiviteit van transforaminale endoscopische chirurgie vergeleken met de open microdiscectomie.
Zie voor de review bijlage 1.

Relevante uitkomstmaten De primaire uitkomstmaten waren pijn-intensiteit, functionele status, globaal ervaren effect, effecten op arbeidsparticipatie en andere uitkomsten als recidieven, complicaties, patiënttevredenheid. Studies werden geïncludeerd in de review als zij > 15 casus beschreven en als de follow-up duur > 6 weken was. Omdat verwacht werd dat er weinig RCT's gevonden zouden worden zijn ook controlled clinical trials en overige observationele studies ingesloten.

Samenvatting van de resultaten

Effectiviteit PTED bij HNP overall In totaal zijn 31 observationele studies over de endoscopische benadering van een lumbale HNP geïncludeerd. De mediane score voor verbetering van pijn in het been of in de rug was 88% en 74%, en voor functionele status 83%. Het globale effect was in 85% bevredigend. Recidief, complicatie of re-operatie trad op bij 1.7, 2.8 en 7% (alle mediaan).

Effectiviteit PTED bij HNP vergeleken met conventionele ingreep

De effectiviteit van transforaminale endoscopische chirurgie vergeleken met open microdiscectomie is onderzocht in 1 RCT en in 5 niet-gerandomiseerde vergelijkende studies. Resultaten uit deze studies gezamenlijk zijn als volgt: pijn reductie trad op bij 71 en 82%, overall verbetering bij 97 en 93%, complicaties bij 6.7 en 0%, en re-operatie bij 6.7 en 3.3%. Deze verschillen tussen de twee technieken waren niet statistisch significant.

RCT

De recent gepubliceerde RCT verdient nadere bespreking:
In de RCT worden twee verschillende endoscopische technieken (interlaminaire en transforaminale benadering) vergeleken met de conventionele microchirurgische techniek.[9] Randomisatie bestond uit het alternerend toewijzen van de ene of de andere behandeling door de studieleiding, op volgorde van aanmelding. Deze methode van randomisatie is niet erg adequaat en verzwakt de methodologische kwaliteit van de studie. De keus voor interlaminair versus transforaminaal hing af van de localisatie van de HNP en andere anatomische karakteristieken. Van de 100 endoscopisch behandelde patiënten werden 41 via de transforaminale toegangsweg geopereerd. In geen van beide behandelgroepen traden ernstige complicaties op. Deze toegangsweg is niet apart geanalyseerd.
Er waren geen verschillen in ernstige postoperatieve complicaties, recidiefkans, pijn- en functionele scores. Directe postoperatieve pijn en percentage milde postoperatieve complicaties waren minder in de endoscopisch behandelde groep, alsmede de periode tot werkhervatting. Gegevens over het aantal patiënten dat werkte, arbeidsstatus en ziekteverzuim in de preoperatieve fase worden echter niet vermeld, zodat niet duidelijk is of de groepen in dit opzicht goed vergelijkbaar waren bij aanvang van de studie.

Kwaliteit studies; hoe verder

De beschreven studies zijn heterogeen met betrekking tot de selectie van patiënten, de operatie-indicaties, de gebruikte technieken, de follow-up duur en de (meetmethodiek van de) uitkomstmaten. De methodologische kwaliteit van de beschreven studies is i.h.a. matig.
Uit de systematische review blijkt dat er weliswaar diverse publicaties zijn verschenen over de endoscopische transforaminale rugchirurgie, maar dat de kwaliteit van vrijwel al deze studies matig is. Dit maakt een eenduidige conclusie over de veiligheid en effectiviteit van de techniek lastig. Met deze methodologische beperkingen als voorbehoud lijken er geen belangrijke verschillen te bestaan tussen de endoscopische transforaminale benadering en de open microdiscectomie. Tegenover eventuele voordelen zoals een kortere revalidatieperiode na endoscopie staan eventuele nadelen zoals (wellicht) een groter percentage recidieven en re-operaties. Maar ondubbelzinnige conclusies zijn op dit moment niet mogelijk. Er is recent één gerandomiseerde

Eerste RCT: goede aanzet voor verder

onderzoek studie gepubliceerd, waar in methodologisch opzicht kanttekeningen bij kunnen worden geplaatst, en waarbij slechts in een minderheid van de patiënten de transforaminale benadering is toegepast. De resultaten van deze vergelijkende studie zijn zeker interessant, met name de combinatie van gelijkwaardige effectiviteit met de gevonden verschillen in werkhervatting. Dit dient nader onderzocht te worden in een RCT van goede methodologische kwaliteit met voldoende lange follow-up. Vanwege de meerkosten van endoscopische chirurgie maar ook de mogelijke effecten op snelheid van werkhervatting is een gelijktijdige kosten-effectiviteitsanalyse de moeite waard.

Standpunten en richtlijnen

Standpunten van buitenlandse zorgverzekeraars/ overheidsinstanties CIGNA (VS) beschouwt endoscopische technieken bij de behandeling van lumbale HNP als experimentele zorg.[10] AETNA (VS) heeft op zijn website geen standpunt over transforaminale techniek. AETNA beschouwt wel de foraminoplastiek (m.b.v. laser) en de micro-endoscopische discectomie als experimenteel. De percutane lumbale discectomie wordt wel, indien aan een aantal voorwaarden is voldaan, vergoed.[11]
NICE (GB), G-BA en IQWIG (Duitsland) en KCE (België) hebben geen standpunt ingenomen over transforaminale endoscopische technieken.[12-15] De NICE heeft een 'guidance' in voorbereiding over lage rugklachten (verwacht in de loop van 2009).

Richtlijnen in binnen- en buitenland De Nederlandse richtlijn LRS (multidisciplinair i.s.m. CBO) wordt op dit moment herzien. Het concept ligt voor bij de wetenschappelijke verenigingen. Uit het concept is boven al geciteerd. Samengevat is de multidisciplinaire werkgroep van mening "dat grootschalige inzet van nieuwe technieken op basis van voorhanden zijnd bewijs niet aan de orde is. Daarvoor dient eerst verder adequaat onderzoek verricht te worden."[4]

Bespreking

Richtlijn lumbale HNP De behandeling van lumbale HNP is in diverse studies uitvoerig onderzocht; de resultaten zijn verwerkt in de huidige multidisciplinaire (concept) richtlijn, die volgens EBRO-methodiek tot stand is gekomen.[16] Belangrijke punten hieruit zijn dat in het merendeel van de gevallen de klachten met een conservatief beleid verdwijnen, en dat er geen goede wetenschappelijke gronden zijn om, indien chirurgie wordt overwogen, nieuwe minimaal invasieve technieken op grote schaal ingang te doen vinden. De endoscopische transforaminale benadering wordt al enige tijd toegepast en biedt naar alle waarschijnlijkheid voordelen in de zin van

Minimaal invasieve technieken nog niet voldoende onderbouwd

sneller herstel en werkhervatting. Over eventuele nadelen (zoals recidiefkans en de kans op ernstige complicaties als duralekkage) in vergelijking met de gouden standaard (microchirurgische discectomie) is echter nog onvoldoende bekend. Dit zou in een RCT van goede kwaliteit en met een voldoende lange follow-up duur (minstens 2 jaar) nader moeten worden onderzocht. De kosten-effectiviteit t.o.v. de standaardbehandeling dient hierin te worden meegenomen. Concluderend is er op dit moment nog onvoldoende bewijs van hoog niveau beschikbaar betr. PTED voor de behandeling van een lumbale HNP. Er zijn geen argumenten te bedenken waarom een RCT van goede kwaliteit niet mogelijk zou zijn: het betreft geen zeldzame aandoening, er zijn geen ethische bezwaren, en er is geen consensus over de waarde van endoscopische technieken binnen de beroepsgroepen. Een RCT is dus zeker niet achterhaald. Daarmee voldoet deze interventie niet aan het criterium zorg conform 'de stand van de wetenschap en praktijk'. Het is mogelijk gebleken om in Nederland goede RCT's op te zetten en uit te voeren betr. de chirurgische behandeling van lumbale HNP.[6-8] Ook w.b. de PTED zou het mogelijk moeten zijn in Nederland een RCT uit te voeren.

Gerandomiseerd onderzoek van goede kwaliteit nodig

Veel expertise binnen Nederland

Innovatieloket

Het CVZ heeft niet de mogelijkheid om nieuwe, veelbelovende interventies die nog niet voldoende zijn uitgekristalliseerd, tijdelijk tot het pakket toe te laten met als doel data te verzamelen voor een definitief oordeel. Daarvoor staan andere fondsen ter beschikking. Wel is recent het 'Innovatieloket' opgericht, een samenwerkingsverband van Nza, ZonMw en CVZ, dat samen met het veld, de mogelijkheden kan verkennen voor het doen van (doelmatigheids)onderzoek. Contactpersoon voor het CVZ is P. de Jong, pjong@cvz.nl.

Inhoudelijke consultatie

De wetenschappelijke verenigingen orthopedie (NOV), neurochirurgie (NVVN), alsmede de Dutch Spine Society (DSS), zijn gevraagd om inhoudelijk commentaar te leveren op voorliggende rapportage. Het gaat hierbij om de inbreng van de verenigingen vanuit wetenschappelijk perspectief. Opmerkingen die voortvloeien uit de behartiging van beroepsbelangen dienen dan ook buiten beschouwing te blijven. De NOV en de DSS hebben geen inhoudelijk commentaar en kunnen zich vinden in de conclusie (bijlage 3 en 4). De NVVN heeft niet binnen de gestelde termijn van ruim 3 weken gereageerd.

Standpunt 'stand van de wetenschap en praktijk'

De vraag of zorg voldoet aan het criterium 'stand van de wetenschap en praktijk' dient bij voorkeur te worden beantwoord a.d.h.v gerandomiseerde studies van voldoende

kwaliteit, groepsgrootte en follow-up duur. Als deze studies niet voorhanden zijn kan op grond van lagere evidence een positieve beslissing worden genomen mits voldoende beargumenteerd is waarom er geen RCT's (meer) mogelijk zijn. In het geval van de lumbale HNP is het CVZ van mening dat het goed mogelijk is om een RCT uit te voeren: het betreft geen zeldzame/levensbedreigende aandoeningen of wilsonbekwame patiënten. Er is bovendien binnen de beroepsgroepen bepaald geen consensus over de waarde van PTED. Bovendien is het in Nederland goed mogelijk gebleken om studies van hoog niveau uit te voeren op het gebied van lage rugklachten (sciatica-MAST o.a.). Om deze redenen is het CVZ van mening dat de PTED als behandeling van lumbale HNP geen zorg is conform stand van de wetenschap en praktijk.

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Bijlage 1 Nellensteijn et al., 2008: Transforaminal endoscopic surgery for symptomatic lumbar disc herniations. A systematic review.

Transforaminal Endoscopic Surgery for Symptomatic Lumbar Disc Herniations.

A systematic review.

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ABSTRACT

Study design. A systematic literature review.

Objective. To assess the effectiveness of transforaminal endoscopic surgery and to compare this with open microdiscectomy in patients with symptomatic lumbar disc herniations.

Summary and Background Data. Many minimally invasive techniques have been developed and performed to treat patients with symptomatic lumbar disc herniations. In the last decades transforaminal endoscopic techniques have been developed to perform discectomy under direct view. Though good results after endoscopic surgical procedures are claimed in the literature, the evidence has not yet been systematically reviewed.

Methods. We performed a comprehensive systematic literature search in cooperation with an experienced librarian. We searched the MEDLINE and EMBASE databases for relevant literature concerning transforaminal endoscopic surgery for symptomatic lumbar disc herniations up to May 2008. Two reviewers independently checked all retrieved titles and abstracts and relevant full text articles for inclusion criteria. Included articles were assessed for quality and outcomes were extracted by the two reviewers independently.

Results. One randomized controlled trial, seven controlled trials and 31 observational studies were identified. Studies were heterogeneous regarding patient selection, indications, operation techniques, follow up period and outcome measures. Overall, 88% of patients reported leg pain reduction and 85% reported the outcome as good or excellent following transforaminal endoscopic surgery. In the controlled studies we found no statistically significant differences in leg pain reduction between the transforaminal endoscopic surgery group (89%) and the open microdiscectomy group (87%); overall improvement was 84% vs. 78%, re-operation rate 6.8% vs. 4.7%, and complication rate 1.5% vs. 1%, respectively. There were also no differences between two different techniques (intradiscal vs intracanal transforaminal endoscopic surgery), nor between different types of herniations (lateral vs. central lumbar disc herniations).

Conclusions. The overall methodological quality of studies that investigate the effectiveness of transforaminal endoscopic surgery for symptomatic lumbar disc herniations is poor. No differences were found on any clinical outcome between transforaminal endoscopic surgery and open microdiscectomy. In order to compare transforaminal endoscopic surgery for symptomatic lumbar disc herniations with open microdiscectomy or other treatments, high quality randomized controlled trials with sufficiently large sample sizes and economic evaluations are needed.
Key words. Lumbar disc herniation, transforaminal, endoscopic surgery, minimally invasive surgery, systematic review.

Introduction

Surgery for lumbar disc herniation can be classified into two broad categories: open vs. minimally invasive surgery and posterior vs. posterolateral approaches.

Mixter & Barr in 1934 were the first authors to treat lumbar disc herniation surgically by performing an open laminectomy and discectomy.[30] With the introduction of the microscope, Yasargil and Caspar refined the original laminectomy into open microdiscectomy [4;44]. Laminectomy and microdiscectomy are open procedures using a posterior approach. Currently, open microdiscectomy is the most widespread procedure for surgical decompression of radiculopathy caused by lumbar disc herniation, but minimally invasive surgery has gained a growing interest. The concept of minimally invasive surgery for lumbar disc herniations is to provide surgical options that optimally address the disc pathology without producing the iatrogenic morbidity associated with open surgical procedures. In the last decades endoscopic techniques have been developed to perform discectomy under direct view and local anaesthesia. Kambin and Gellmann in 1973 [15] in the United States and Hijikata in Japan in 1975 [9] independently performed a non-visualized, percutaneous central nucleotomy for the resection and evacuation of nuclear tissue via a posterolateral approach. In 1983, Forst & Housman reported the direct visualisation of the intervertebral disc space with a modified arthroscope [6]. Kambin published the first intraoperative discoscopic view of a herniated nucleus pulposus in 1988 [14]. In 1989 and 1991, Schreiber et al. described "percutaneous discoscopy" a biportal endoscopic posterolateral technique with modified instruments for direct view [38 37]. In 1992, Mayer introduced percutaneous endoscopic laser discectomy (PELD) combining forceps and laser [29]. With the further perfection of scopes (e.g. variable angled lenses and working channel for different instruments) the procedure became more refined. Removal of sequestered non-migrated fragments became possible using a biportal approach [18]. The concept of posterolateral endoscopic lumbar nerve decompression changed from indirect central nucleotomy (inside-out, in which fragments are extracted through an annular fenestration outside the spinal canal) to transforaminal direct extraction of the non-contained and sequestered disc fragments from inside the spinal canal. In this article, the technique of direct nucleotomy is described as intradiscal and the technique directly in the spinal canal is described as intracanal technique; both are transforaminal approaches.

The indications for transforaminal endoscopic treatment became comparable to those of hemilaminectomy and discectomy [5;17;27]. In order to reach the posterior part of the epidural space, the superior articular process of the facet joint is usually the obstacle. Yeung and Knight used a holmium-YAG (yttrium-aluminum-garnet)- laser to achieve foraminoplasty for ablation of bony and soft tissue for decompression and enhanced access and to improve intracanal visualization [45 22]. Yeung developed the commercially available Yeung Endoscopic Spine System (YESS) in 1997 [46] and Hoogland in 1994 developed the Thomas Hoogland Endoscopic Spine System (Thessys). With this latter system it is possible to enlarge the intervertebral foramen near the facet joint with special reamers to reach intracanal extruded and sequestered disk fragments and decompress foraminal stenosis [10].

Recently, also another minimally invasive technique, microendoscopic discectomy (MED), has been developed. In MED a microscope is used and the spine is approached from a posterior direction and not transforaminal. Therefore this technique is not considered in the current systematic review.

Endoscopic surgery for lumbar disc herniations has been available for more than 30 years, but at present a systematic review of all relevant studies on the effectiveness of transforaminal endoscopic surgery in patients with symptomatic lumbar disc herniations is lacking.

Insert figure 1 here (zie tables article LDH)

Methods

Objective

The objective of this systematic review was to assess the effectiveness of transforaminal endoscopic surgery in patients with symptomatic lumbar disc herniations. Therefore we formulated two main research questions and two sub-questions;

1) What is the effectiveness of transforaminal endoscopic surgery?
   1a) What is the effectiveness of the older intradiscal transforaminal technique and the more recently developed intracanal transforaminal technique?
   1b) What is the effectiveness of transforaminal endoscopic surgery for the different types of herniations (mere lateral herniations versus central herniations versus all types of lumbar disc herniations)?
2) What is the effectiveness of transforaminal endoscopic surgery compared to open microdiscectomy?

For this systematic review we used the method guidelines for systematic reviews as recommended by the Cochrane Back Review Group[43]. Below the search strategy, selection of the studies, data extraction, methodological quality assessment, and data analysis are described in more detail. All these steps were performed by two independent reviewers and during consensus meetings potential disagreements between the two reviewers regarding these issues were discussed. If they were not resolved a third reviewer was consulted.

Search strategy

An experienced librarian performed a comprehensive systematic literature search. The MEDLINE and EMBASE databases were searched for relevant studies from 1973 to April 2008. The search strategy consisted of a combination of keywords concerning the technical procedure and keywords regarding the anatomical features and pathology (Table 1). We conducted two reviews, one on lumbar disc herniation and one on spinal stenosis, and combined the search strategy for these two reviews for efficiency reasons. These keywords were used as MESH headings and free text words. The full search strategy is available upon request.

Insert Table 1 here

Selection of studies

The search was limited to English, German and Dutch studies, because these are the languages that the review authors are able to read and understand. Two review authors independently examined all titles and abstracts that met our search terms and reviewed full publications, when necessary. Additionally, the reference sections of all primary studies were inspected for additional references. Studies were included that describe transforaminal endoscopic surgery for adult patients with symptomatic lumbar disc herniations. As we expected only a limited number of randomized controlled trials in this field, we also included observational studies (non-randomised controlled clinical trials, cohort studies, case control studies and retrospective patient series). To be included, studies had to report on more than 15 cases, with a follow up period of more than six weeks.

Data extraction
Two review authors independently extracted relevant data from the included studies regarding design, population (e.g. age, gender, duration of complaints before surgery, etc), type of surgery, type of control intervention, follow-up period and outcomes. Primary outcomes that were considered relevant are: pain intensity (e.g., visual analogue scale or numerical rating scale), functional status (e.g., Roland Morris Disability Scale, Oswestry Scale), global perceived effect (e.g., McNab score, percentage patients improved), vocational outcomes (e.g., percentage return to work, number of days of sick leave), and other outcomes (recurrences, complication, re-operation and patient satisfaction). We contacted primary authors where necessary for clarification of overlap of data in different articles.

Methodological quality assessment
Two review authors independently assessed the methodological quality of the included studies. Controlled trials were assessed using a criteria list recommended by the Cochrane Back review group as listed in Table 2 [43]. Non-controlled studies were assessed using a modified 5 point assessment score as listed in Table 3.
Disagreements were resolved in a consensus meeting and a third review author was consulted if necessary.

Insert Tables 2 and 3 here

Data analysis
In order to assess the effectiveness of transforaminal endoscopic surgery and to compare it to open microdiscectomy the results of outcome measures were extracted from the original studies. Outcome data of some studies were recalculated, because the authors of the original papers did not handle drop outs, lost to follow up and/or failed operations adequately. If a study reported several follow-up intervals, the outcome of the longest follow-up moment was used.
Because of the heterogeneity of the study populations, technical differences of the various endoscopic interventions and differences in outcome measures, instruments and follow-up moments, statistical pooling was not performed. We present the median and range (min-max) of the results of the individual studies for each outcome measure.

Results
Search and selection
2513 references were identified in MEDLINE and EMBASE that were potentially relevant for the reviews on lumbar disc herniation and spinal stenosis. After checking titles and abstracts a total of 123 full text articles were retrieved that were potentially eligible for this review on lumbar disc herniation. Reviewing the reference lists of these articles resulted in an additional 17 studies. Some patient cohorts were described in more than one article. In these cases, all articles were used for the quality assessment of the study, but outcome data reporting the longest follow up was used. After scrutinizing all full text papers, 39 studies reported in 45 articles were included in this review. Sixteen studies (41%) had a mean follow-up of more than two years. The characteristics and outcomes of the included studies are presented in Tables 4-7.

Insert tables 4-7 here

Type of studies and methodological quality
A total of six prospective controlled studies and two retrospective controlled studies were included. Furthermore, 12 studies were designed as prospective cohort (without

control group) and there were 19 retrospective studies (also without control group). When it was unclear whether the study was prospective or retrospective, the study was considered retrospective.
Of the six prospective controlled studies, four compared transforaminal endoscopic surgery with open discectomy or microdiscectomy. All four were reported as randomized trials, but in three of them the method of randomization was inadequate. Mayer and Brock[28] did not describe the randomization method at all, and Krappel et al.[23] and Ruetten et al.[34] did not randomize but allocated patients alternately to transforaminal endoscopic surgery or microdiscectomy. Only in the study by Hermantin et al.[8] randomization was adequately performed in 60 patients with non-sequestered lumbar disc herniations. This was the only study that was considered having a high methodological quality and a low risk of bias, However, the generalizability of this study is poor because patients with a specific type of herniated disc were selected and results are consequently not directly transferable to all patients with lumbar disc herniations.

Insert tables 8-11 here

Outcomes
1) What is the effectiveness of transforaminal endoscopic surgery?

No randomized controlled trials were identified. Outcomes of 31 observational studies are presented in Table 12. The median overall improvement of leg pain (VAS) was 88% (range 65-89%), global perceived effect (MacNab) 85% (72-94%), return to work of 90%, recurrence rate 1.7%, complications 2.8% and re-operations 7%.

Insert table12 here

1a) What is the effectiveness of the older intradiscal technique and the more recently developed intracanal technique?

No randomized controlled trials were identified. In table 13 the results of 14 studies describing the intradiscal technique and 16 studies describing the intracanal technique are presented. The median leg pain improvement (VAS) was 83% (78-88%) for the intradiscal versus 88% (65-89%) for the intracanal technique and the results for global perceived effect were (MacNab) 85% (78-89%) versus 86% (72-93%), respectively. Other outcomes are listed in table 13.

Insert table 13 here

1b) What is the effectiveness of transforaminal endoscopic surgery for the different types of herniations (mere lateral herniations versus central herniations versus all types of lumbar disc herniations)?

No randomized controlled trials were identified. Six non-controlled studies described surgery for far lateral herniations, one for central herniations and in 15 studies all types of herniations were included. The median GPE (MacNab) was 86% (85-86%) for lateral herniations, 91% for central herniations and 83% (79-94%) for all types of herniations. Other outcomes are listed in table 14.

Insert table14 here

2) What is the effectiveness of transforaminal endoscopic surgery compared to open microdiscectomy?

Six controlled studies (N = 720) were identified that compared transforaminal endoscopic to open microdiscectomy. Four of them were prospective and two retrospective studies.
Only one high quality, randomized controlled trial (N = 60) was identified that compared pure intradiscal technique with open laminotomy. There were no statistically significant differences between the two groups. The pain reduction in the transforaminal endoscopic surgery group was 71% vs. 82% in the open laminotomy group after on average 32 months follow-up. Overall improvement was 97% vs. 93%, re-operation rate 6.7% vs. 3.3%, and complication rate 6.7% vs. 0%, respectively. Overall the controlled studies found no differences in outcomes: leg pain reduction in the transforaminal endoscopic surgery group was 89% versus 87% in the open microdiscectomy group, overall improvement (GPE) was 84% versus 78%, re-operation rate 6.8% versus 4.7%, and complication rate 1.5% versus 1.0%, respectively (table 16). In none of the studies there were any statistically significant differences between the intervention groups on pain improvement and global perceived effect. Ruetten et al.[34] (n=200) reported statistically significant differences on return to work, but this was a secondary outcome and it was unclear how many subjects in each group had work and if groups were comparable regarding work status and history of work absenteeism at baseline.

In one study transforaminal endoscopic surgery was compared with the same operation combined with chymopapain, and one study compared endoscopic surgery with chemonucleolysis and automated discectomy (Table 7).

Insert table 15 here

Discussion
In the current review all available evidence regarding the effectiveness of transforaminal endoscopic surgery was identified and systematically summarised. Pain improvement and global perceived effect (GPE) were the most frequently reported outcomes. There were no important differences between the intradiscal technique and the intracanal technique and nor were there any differences for different types of herniations. Overall, transforaminal endoscopic surgery showed similar outcomes as open microdiscectomy.
This study has a number of limitations that should be considered when drawing conclusions regarding the effectiveness of transforaminal endoscopic surgery for lumbar disc herniations. The included studies in this review were heterogeneous with regard to the selection of patients, the indications for surgery, the surgical techniques used, and the duration of follow up. Furthermore, different outcome measures were used in the studies and different instruments used for the same outcomes. Below we will elaborate on the most important sources of heterogeneity in more detail.

Selection of patients
Patient selection and in/exclusion criteria were often not clearly described. Among others, this includes physical examinations, radiological findings, the period and type of pre-operative therapies and duration of symptoms. In most studies, patients received some type of preoperative conservative treatment for a few months, but the exact content of the conservative treatment was not specified. Also, duration of symptoms before surgery differed among studies and in some studies patients with

acute onset (<2 weeks) of complaints were also included. In some studies only "virgin discs" were included, while in others a previous disc operation was not an exclusion criterion or it was not mentioned if patients with a previous disc operation were excluded or not. In two studies only recurrent herniations after open microdiscectomy were treated with transforaminal endoscopic surgery.[3,11] Some studies included only lateral or central herniations whereas others included all herniations. Given this, there is much heterogeneity in patient selection between the studies which hinders comparability between studies.

Techniques
Indications for endoscopic surgery have changed over time with the introduction of new techniques, scopes and instruments. Initially non-contained, sequestered and central herniations were exclusion criteria for endoscopic surgery and L5-S1 level herniations were not always possible to reach as the diameter of the foramen intervertebrale decreases in the lumbar area from cranial to caudal [33]. In the earlier phase of development of transforaminal endoscopic surgery, discectomy was performed through a fenestration in the lateral annulus and the focus was limited on central debulking and reduction of intradiscal pressure. Later, the hernia was extracted from the spinal canal with or without an intradiscal debulking. When performing a foraminoplasty, enhanced access can be created and the L5-S1 level can be better reached. We compared the effect of discectomy performed by the intradiscal technique with the later developed intracanal technique. We found comparable outcomes for both techniques, though indications for the intracanal techniques are wider as patients with non-contained large extraligamentous, sequestered and central fragments and even with lateral stenosis are often included.
Far lateral herniations occur in 3-11% of lumbar disc herniations and usually cause severe sciatic pain [1;2;31;32]. Some reports mentioned more difficulty to assess an extraforaminal herniated lumbar disc through an open procedure and it is often associated with substantial bone removal [25]. As transforaminal endoscopic surgery is a posterolateral approach to the spine, lateral herniations might be more easily reached [42]. With lateral herniations the angle of the instruments should be steeper and thus the insertion closer to the midline[5;12]. We compared the effect of transforaminal endoscopic surgery for lateral herniations with central and all herniations. All outcomes were comparable.

Methodological quality
Most studies had major design weaknesses and the quality of the identified studies was poor, indicating that studies had a high risk of bias. Only one adequately randomized controlled trial was identified. In most studies randomization was not performed at all, not performed adequately or not described adequately. Obviously, patients and surgeons cannot be blinded for the surgical intervention. However, many other important quality items were also not met by the majority of studies. Although transforaminal endoscopic surgery for lumbar disc herniation was introduced about 30 years ago and many patients have undergone this intervention since its introduction, only one randomized controlled trial with a low risk of bias has been published. Only high quality, randomized controlled trials with sufficiently large sample sizes comparing transforaminal endoscopic surgery to other surgical techniques for lumbar disc herniations can provide strong evidence regarding its effectiveness. Preferably these trials should be conducted by independent research institutes.

Outcome measures

The most frequently used outcome measures in the included studies are the VAS score for pain and the MacNab score for global perceived effect. In order to compare the VAS scores across studies, we calculated the percentage of improvement between the postoperative and preoperative scores. The MacNab score is a 4 point scale ranging from 1 (excellent); 2 (good), 3 (fair) to 4 (poor). In most studies 'excellent' and 'good' were combined and labelled 'satisfactory'. Though a close inspection of the score 'good' on the MacNab, reveals that patients still have occasionally ongoing symptoms, sufficient to interfere with normal work or capacity to enjoy leisure activities [26]. We considered labelling this as a 'satisfactory' outcome was somewhat too positive. Therefore, whenever possible, we presented the original MacNab scores.

While some studies used validated outcomes (e.g. the Oswestry Disability Questionnaire for low back pain specific functional disability) others used non-validated outcomes, or did not describe at all how disability and improvement were measured. Future trials should use valid and reliable instruments to measure the primary outcomes.

Adverse effects

Recurrences

Eighteen studies reported recurrence rates of lumbar disc herniations, but the definition of recurrence varied. For this review we defined a recurrence as a re-appearance of a symptomatic lumbar disc herniation at the same level after a pain-free interval of longer than one month. When in a study the symptomatic hernia appeared within a month we considered it a re-operation. In the present review, we found a median recurrence rate of 1.7% (range 0-12%.) The reported recurrence rate in the literature of open microdiscectomy is similar with reported ranges from 5% to 11%[42]. In the controlled studies we found no significant difference in recurrences between the two techniques.

Re-operation

In the non controlled studies we found a median re-operation rate of 7% (0-27%). In the controlled studies we found no significant differences in re-operation percentages between endoscopic transforaminal surgery and open microdiscectomy (6.8 vs. 4.7%). As in most surgical interventions, adequate patient selection and accurate diagnosis seem very important. Most common cause for re-operations is persistent complaints due to missed lateral bony stenosis and remnant fragments[16].

Complications

One of the suggested advantages of transforaminal endoscopic surgery compared with open microdiscectomy is a lower complication rate. [20] Because of the small incision and minimal internal tissue damage the revalidation period is supposed to be shorter and scar tissue minimized. [21] In the current review, we found no severe neurological injury and a mean percentage of complications after transforaminal endoscopic surgery of 2.8%. There were no differences in serious complications between endoscopic surgery and open microdiscectomy. Most reported complications were transient dysaesthesia or hypaesthesia.

Also disadvantages have been reported. Transforaminal endoscopic surgery has a steep learning curve that requires patience and experience, especially for those unfamiliar with percutaneous techniques. In some studies the patients operated at the beginning of the learning curve had worse outcome [7;13;19;39;42]. Some patients may experience local anaesthesia as a disadvantage. In three studies the operations were performed under general anaesthesia[34;35;40]. Comprehensive preoperative information

about the intervention and permanent communication and constant observation during the operation is of major importance.

Future research
Only randomized controlled trials that are adequately designed, conducted and reported and that have a low risk of bias will provide sufficient evidence regarding the effectiveness of transforaminal endoscopic surgery for lumbar disk herniation. High quality, randomized controlled trials with sufficiently large sample sizes that compare the effectiveness of transforaminal endoscopic surgery with open microdiscectomy for lumbar disc herniations are needed. The short hospital stay, shorter revalidation period and earlier return to work may result in an economic advantage, though this has never been evaluated. Economic evaluations should be performed alongside these trials to assess the cost-effectiveness and cost-utility of transforaminal endoscopic surgery.

Conclusion
This systematic review assessed the effectiveness of transforaminal endoscopic surgery. Of the 39 studies included in this review, most studies had major design weaknesses and were considered having a high risk of bias. Only one adequately randomized controlled trial was identified, but this trial had poor generalizability. Studies were heterogeneous regarding patient selection, indications, operation techniques, follow up period and outcome measures. Overall, the studies reported 88% leg pain reduction and 85% reported the outcome as satisfactory. No differences were found in outcome between the intradiscal technique and the intracanal technique or for lateral versus central lumbar disc herniations. No significant differences in pain, overall improvement, patient satisfaction, recurrence rate, complications and re-operations were found between transforaminal endoscopic surgery and open microdiscectomy.

Key points
- Although 39 studies were identified, none of these studies was a large, well-designed randomised controlled trial with a low risk of bias and a high generalizability.
- The overall methodological quality of studies that investigate the effectiveness of transforaminal endoscopic surgery is poor and studies are heterogeneous regarding selection of patients, indications, techniques, follow up, outcome measures and study design.
- The reported outcomes of transforaminal endoscopic surgery are 88% improvement on leg pain (VAS) and 85% on global measure of improvement (MacNab).
- No important differences were found in the effectiveness of transforaminal endoscopic surgery as compared to open microdiscectomy regarding pain, global perceived effect, patient satisfaction, recurrence rate and re-operations.
- In order to compare transforaminal endoscopic surgery for symptomatic lumbar disc herniations with open microdiscectomy or other treatments, high quality randomized controlled trials with sufficiently large sample sizes and economic evaluations evaluating cost-effectiveness are direly needed.

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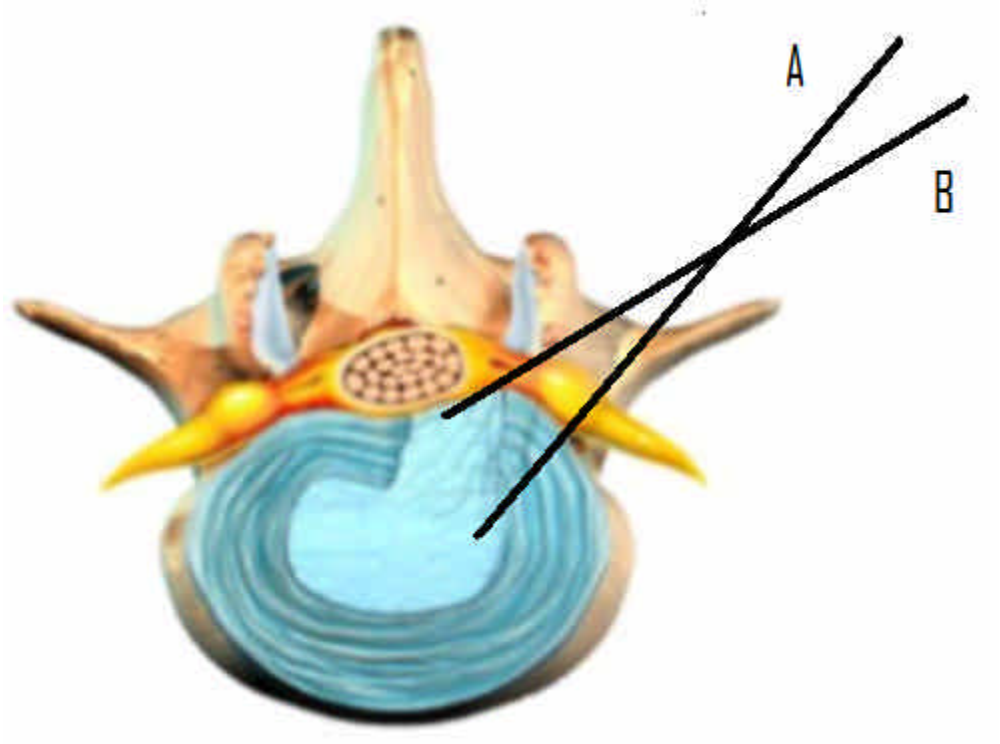

Figure 1: different posterolateral approaches to the lumbar disc.
A: the intradiscal technique, B: the intracanal technique.

Table 1:Selection of terms used in our search strategy

Technical procedure	**anatomical features / disorder**
Endoscopy	Spine
Arthroscopy	Back
Video-Assisted Surgery	Back pain
Surgical Procedures, Minimally Invasive	Spinal diseases
Microsurgery	Disc displacement
Transforaminal	Intervertebral disc displacement
Discectomy	Spinal cord compression
Percutaneous	Sciatica
Foraminotomy, Foraminoplasty	Radiculopathy
Discoscopy	

Table 2: criteria list for quality assessment of controlled studies

A	Was the method of randomization adequate?	Y	N	?
B	Was the treatment allocation concealed?	Y	N	?
C	Were the groups similar at baseline regarding the most important prognostic indicators?	Y	N	?
D	Was the patient blinded to the intervention?	-	N	-
E	Was the care provider blinded to the intervention	-	N	-
F	Was the outcome assessor blinded to the intervention?	Y	N	?
G	Were co-interventions avoided or similar?	Y	N	?
H	Was the compliance acceptable in all groups?	Y	N	?
I	Was the drop out rate described and acceptable?	Y	N	?
J	Was the timing of the outcome assessment in all groups similar?	Y	N	?
K	Did the analysis include an intention to treat analysis?	Y	N	?

A A random (unpredictable) assignment sequence. Examples of adequate methods are computer generated random number table and use of sealed opaque envelopes. Methods of allocation using date of birth, date of admission, hospital numbers, or alternation should not be regarded as appropriate.

B Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.

C In order to receive a 'yes', groups have to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of patients with neurologic symptoms, and value of main outcome measure(s).

D The reviewer determines if enough information about the blinding is given in order to score a 'yes'.

E The reviewer determines if enough information about the blinding is given in order to score a 'yes'.

F The reviewer determines if enough information about the blinding is given in order to score a 'yes'.

G Co-interventions should either be avoided in the trial design or similar between the index and control groups.

H The reviewer determines if the compliance to the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s).

I The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for short-term follow-up and 30% for long-term follow-up and does not lead to substantial bias a 'yes' is scored. (N.B. these percentages are arbitrary, not supported by literature).

J Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.

K All randomized patients are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of non-compliance and co-interventions.

Table 3: criteria list for quality assessment of non-controlled studies

A	Patient selection/inclusion adequately described ?	Y	N	?
B	Drop out rate described ?	Y	N	?
C	Independent assessor ?	Y	N	?
D	Co-interventions described ?	Y	N	?
E	Was the timing of the outcome assessment similar?	Y	N	?

A: All the basic elements of the study population are adequately described; i.e. demography, type and level of disorder, physical and radiological inclusion and exclusion criteria, pre-operative treatment and duration of disorder
B: Are the patients of whom no outcome was obtained, described in quantity and reason for drop out.
C: The data was assessed by an independent assessor.
D: All co-interventions in the population during and after the operation are described.
E: Timing of outcome assessment should be more or less identical for all intervention groups and for all important outcome assessments.

Table 4: Prospective controlled studies

Study/author *Methodology*	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
Hermantin et al. 1999 [7] *Randomized* *N=60*	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Sequestration Previous surgery (same level) Central or lateral stenosis	**Type:** Intracanal LDH **Level:** Single level L2-S1	**Index:** Arthroscopic microdiscectomy Pure intradiscal technique *Kambin technique* *biportal: N=2* N=30 □8 □22 mean 39 yr, range 15-66 **Control**: Open Laminotomie N=30 □13 □17 mean 40 yr, range 18-67	**Follow up I:** mean: 31 mos (range:19-42), 0% lost to follow up . **C:** mean: 32 mos (range: 21-42), 0% lost to follow up **Pain** (VAS) **I:** pre-op.: 6,6, follow up: 1.9, difference: 4.7 =71% **C:** pre-op.: 6.8, follow up: 1.2, difference: 5.6 =82% **Return to work** (mean) **I:** 27, **C:** 49 days **GPE** (undear instrument) **I:** 97%, **C:** 93% excellent + good **PS** (very satisfied) **I:** 73%, **C:** 67% **Complications I:** 6.7%, **C:** 0% **Re-operations I:** 6.7%, **C:** 3.3%	
Hoogland et al. 2006 [11] *Non-Randomized (birth date)* *N=280*	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Obesity Previous surgery (same level)	**Type:** All LDH **Level:** Single level L2-S1	**Index**: transforaminal endoscopic discectomy Intradiscal & intracanal technique *Thessys instrumentation* N=142 □50 □92 mean 41 yr, range 18-60 **Control**: transforaminal endoscopic discectomy combined with injection of low dose (1000U) chymopapain. N=138 □44 □94 mean 40.3 yr, range 18-60	**Follow up I:** 24 mos, 16% lost to follow up **C:** 24 mos, 16% lost to follow up **Pain leg** (VAS) **I:** pre-op.: 8.0, follow up: 2.0, difference: 6.0 =75% **C:** pre-op.: 8.2, follow up: 1.9, difference: 6.3 =77% **Pain back** (VAS) **I:** pre-op.: 8.2, follow up: 2.6, difference: 5.6 =68% **C:** pre-op.: 8.2, follow up: 2.8, difference: 5.4 =66% **GPE** (MacNab) **I:** 16% excellent, 33.8% good, 0.9% poor **C:** 63% excellent, 27% good, 0.9% poor **NS** **PS I:** 85%, **C:** 93% **S** **Recurrence I:** 7.4%, **C:** 4.0% **Complications I:** 2.1%, **C:** 2.2% **NS** **Re-operations I:** 6.1%, **C:** 1.6%	
Krappel et al. 2001 [21] *randomized (Alternating)* *N=40*	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Sequestration High iliac crest	**Type:** not specified **Level:** Single level L4-S1	**Index**: Endoscopic transforaminal nucleotomy Pure intradiscal technique *Mathews technique* *Sofamor-Danek endoscope* N=20 □? □? mean 41 yr, range 36-54	**Follow up I:** range: 24-36 mos, 5% lost to follow up **C:** range: 24-36 mos, 0% lost to follow up **GPE** (MacNab) **I:** 16% excellent, 68% good, 0% poor **C:** 15% excellent, 60% good, 0% poor **NS** **Return to work I:** 100%, **C:** 100% **Recurrence I:** 5%, **C:** 0%	

Study/author Methodology	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
			Control: Open nucleotomy N=20 □?□? mean 39 yr, range 25-43	**Complications** I: 0%, C 0% **Re-operations** I: 5%, C 0%	
Lee et al. 1996 [24] *Non-randomized (Preference of surgeon)* *N=300*	**Inclusion criteria** Radiculopathy **Exclusion criteria** Sequestration	**Type**: not specified **Level:** Single level L3-S1	**Index**: percutaneous endoscopic laser discectomy (PELD) N=100 □35 □65 Pure intradiscal technique *Kambin technique* **Control 1**: Chemonucleolysis N=100 □24 □76 **Control 2**: Automated percutaneous discectomy N=100 □28 □72	**Follow up** 12 mos, 0% lost to follow up **GPE** (Modified MacNab) **I:** 29%, **C1:** 20%, **C2:** 18% excellent **I:** 39%, **C1:** 35%, **C2:** 30% good **I:** 9%, **C1:** 18%, **C2:** 20% poor **Return to work (6wks)** **I:** 81%, **C1:** 67%, **C2:** 66% **Complications** **I:** 4%, **C1:** 10%, **C2:** 3% **Re-operations** **I:** 9%, **C1:** 18%, **C2:** 20%	Authors included N=3 patients in satisfactory group after re-operation. These were labelled as "adverse effects" and "re-opera-tions" in this review
Mayer and Brock 1993 [29;30] *randomization not specified* *N=40*	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Sequestration Previous surgery (same level) Cauda syndrome Segmental instability	**Type**: not specified **Level:** Single level L2-L5	**Index**: Percutaneous endoscopic discectomy Pure intradiscal technique *Modified Hjikata instrumentation* N=20 □8 □12 mean 40 yr, range 12-55 **Control**: Open Microdiscectomy N=20 □6 □14 mean 42 yr, range 19-63,	**Follow up** 24 mos, 0% lost to follow up **GPE** (S/S-score) **I:** 70% satisfactory, 0% poor **C:** 65% satisfactory, 15% poor **Patient satisfaction** **I:** 55%, **C:** 55% **Recurrence** **I:** 5%, **C:** 0% **Complications** **I:** 0%, **C:** 5% **Re-operations** **I:** 15%, **C:** 5%	
Ruetten et al. 2008[35] *Randomized (alternating by independent person)* N=200	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Not specified	**Type**: All LDH **Level:** Single level L1-S1	**Index**: Endoscopic transforaminal and interlaminar lumbar discectomy Intracanal technique *YESS, Richard Wolf instrumentation* N=100 **Control**: Open Microdiscectomy N=100 **Overall** N=200 □116 □84 mean 43 yr, range 20-68	**Follow up** **I:** 24 mos, 8% lost to follow up **C:** 24 mos, 8% lost to follow up **Pain leg** (VAS) **I:** pre-op.:75, follow up:8, difference:67 =89% **C:** pre-op.:71, follow up: 9, difference: 62 =87% **Pain back** (VAS) **I:** pre-op.:19, follow up:11, difference:8 =42% **C:** pre-op.:15, follow up: 18, difference: -3 = -8.3% **Functional status** (ODI) **I:** pre-op.:75, follow up:20, difference:55=73% **C:** pre-op.:73, follow up:24, difference:49= 67% **Patient satisfaction** **I:** 97%, **C:** 88%	Authors excluded N=6 from analyses due to revision surgery These were taken into account in this review N= 41 were operated via a transforaminal endoscopic technique N=59 patients were operatie via an

Study/author *Methodology*	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
				Return to work (mean) **I:** 25 days **C:** 49 days **S** **Recurrence** **I:** 6.6% **C:** 5.7% **NS** **Complications** **I:** 3%, **C:** 12% **S** **Re-operations** **I:** 6.8% **C:** 11.5	interlaminar endoscopic technique

Table 5: Retrospective controlled studies

Study *Methodology*	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	Comment
Kim et al. 2007 [18] surg neurol *All patients that underwent the procedures in a certain period*	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Extraforaminal LDH Previous surgery (same level) Spinal stenosis Segmental instability Spondylolisthesis	**Type:** central, paramedian and foraminal LDH **Level:** Single level L1-S1	**Index**: Percutaneous transforaminal endoscopic discectomy (PTED) Intradiscal & intracanal technique *YESS, Richard Wolf instrumentation* N=295 □107 □188 mean 35 yr, range 13-83 **Control**: Open microdiscectomy N=607 □215 □392 mean 44 yr, range 17-80	**Follow up** mean: 23.6 mos (range: 18-36), **I:** 2.5%, **C**: 3.5% non responders **GPE** (MacNab) **I:** 47% excellent, 37% good, 5.4% poor **C:** 48% excellent, 37% good, 6.6% poor NS **Recurrence** **I:** 6.4% **C:** 6.8% NS **Complications** **I:** 3.1% **C:** 2.0% NS **Re-operations** **I:** 9.5% **C:** 6.3% NS	
Lee et al. 2006 [23] *Randomly selected patients with follow up > 3 years in both groups*	**Inclusion criteria** Radiculopathy **Exclusion criteria** Stenosis Segmental instability	**Type:** not specified **Level:** Single level L4-S1	**Index**: Percutaneous endoscopic lumbar discectomy (PELD) Pure intradiscal technique *instrumentation not specified* N=30 □8 □22 mean 40 yr, range 22-67 **Control**: Open microdiscectomy N= 30 □8 □22 mean 40 yr, range 20-64	**Follow up** **I:** mean: 38 mos (range: 32-45), 0% lost to follow up **C:** 35-42 (36) months, 0% non responders **GPE** (MacNab) **I:** 80% excellent, 17% good, 3.3% poor **C:** 78% excellent, 17% good, 0% poor **Complications** **I:** 0%, **C:** 0% **Re-operations** **I:** 3.3%, **C:** 0%	Primary outcome of the study was a radiologic evaluation

Table 6: prospective cohort studies

Study	Main inclusion criteria Main exclusion criteria	Number of participants Type / level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	Comment
Hoogland et al. 2008 [12]	**Inclusion criteria** Previous surgery (same level) Recurrent discherniation Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Not specified	N=262 □76 □186 mean 46 yr range 18-80 **Type:** All LDH **Level:** Single level L2-S1	Endoscopic transforaminal discectomy (ETD) Intradiscal & intracanal technique *Thessys instrumentation*	**Follow up** 24 mos, 9% lost to follow up **Pain leg** (VAS) pre-op.:8.5, follow up: 2.6, difference: 5.9 =69% **Pain back** (VAS) pre-op.:8.6, follow up: 2.9, difference: 5.7 =66% **GPE** (MacNab) 31% excellent, 50% good, 2.5% poor **Patient satisfaction** 51% excellent, 35% good, 5% poor **Recurrence** 6.3% **Complications** 1.1% **Re-operations** 7%	Authors included only patients with recurrent LDH, more than 6 months after open microdiscectomy or endoscopic surgery
Hoogland and Schenkenbach 1998;[10] Schenkenbach and Hoogland 1999 [39]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Not specified	N=130 □43 □87 Mean 39 yr **Type:** All LDH **Level:** Single level L2-S1	Endoscopic transforaminal discectomy (ETD) Intradiscal & intracanal technique *Thessys instrumentation*	**Follow up** 12 mos, 5.1% lost to follow up **Pain leg** (VAS) difference 5.9 **Pain back** (VAS) difference 5.4 **GPE** (MacNab) 56% excellent, 27% good, 6% poor **Return to work (6 weeks)** 70% **Complications** 1.5% **Re-operations** 4.6%	
Kafadar et al. 2006 [15]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Previous surgery (same level) Spinal stenosis Segmental instability Calcified LDH	N=42 □2 □40 range 18-74 yr **Type:** All LDH **Level:** Single level L4-L5	Percutaneous endoscopic transforaminal discectomy (PETD) Pure intradiscal technique *Karl Storz instrumentation*	**Follow up** mean: 15 mos (Range: 6-24) (SD: 4), 0% lost to follow up **GPE** (S/S score) 14% excellent, 36% good 36% poor **Recurrence** 0% **Complications** 45% **Re-operations** 17%	Authors excluded N=8 from analyses due to stopped procedures. These were taken into account in this review
Kambin 1992; Kambin 1998 [16;17]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Large extraligamental LDH Previous surgery (same level) Cauda syndrome Degenerative disc	N=175 □76 □99 **Type:** All LDH **Level:** Single level L2-S1	Arthroscopic microdiscectomy and selective fragmentectomy Pure intradiscal technique *Kambin technique* *Biportal n=59*	**Follow up** mean: 48 mos (range: 24-78), 3.4% lost to follow up **GPE** (Modified Presby St Luke score) 77% excellent, 11% good, 12% failed **Return to work (3wks)** 95% **Complications** 5.3% **Re-operations** 7.7%	
Knight et al. 1999; Knight et al 2001 [19;20]	**Inclusion criteria** Prior disc surgery n=75 Back pain Leg pain	N=250 □? □? mean 48 yr, range 21-86	Endoscopic laser foraminoplasty (ELF) Intradiscal & intracanal	**Follow up** mean: 30 mos (range: 24-48) (SD 5.87), 3.2% lost to follow up **Pain** (VAS >50% improvement) 56%	Authors included also degenerative and lateral

Study	Main inclusion criteria Main exclusion criteria	Number of participants Type / level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	Comment
	Radiculopathy **Exclusion criteria** Cauda syndrome Painless motor deficit	**Type:** All LDH **Level:** single & multiple level L2-S1	techniqu e *Richard Wolf instrumentation*	**Functional status** (ODI) 60% improved ≥50% **Complications** 0.8% **Re-operations** 5.2%	stenosis in this study
Lee et al. 2007 [22]	**Inclusion criteria** Radiculopathy Neurological deficit Non-contained or sequestered LDH **Exclusion criteria** Previous surgery (same level) Central or lateral stenosis Segmental instability	N=116 □43 □73 mean 36 yr, range 18-65 **Type:** not specified **Level:** Single level L2-S1	Percutaneous endoscopic lumbar discectomy (PELD) Intradiscal & intracanal techniqu e *YESS, Richard Wolf instrumentation*	**Follow up** mean: 14.5 mos (range: 9-20), 0% lost to follow up **Pain leg** (VAS) pre-op.:7.5, follow up: 2.6, differen ce: 4.9 =65% **GPE** (ModifiedMacNab) 45% excellent, 47% good, 6.0% poor **Return to work** Average 14 days, range 1-48 days **Recurrence** 0% **Complications** 0% **Re-operations** 0%	
Morgenstern et al. 2005 [31]	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Sequestration	N=144 □48 □96 mean 46 yr range 18-76 **Type:** All LDH **Level:** Multiple level n=60 L1-S1	Endoscopic spine surgery Intradiscal & intracanal techniqu e *YESS, Richard Wolf instrumentation*	**Follow up** mean: 24 mos (range: 3-48), 0% lost to follow up **GPE** (MacNab) 83% excellent and good, 3% poor **Complications** 9% **Re-operations** 5.6%	Primary outcome of this study was to compare normal versus intensive physical therapy post operative rev alidation
Ramsbacher et al. 2000 [33]	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Far migrated sequesters Central or lateral stenosis high iliac crest	N=39 □21 □18 mean 50 yr **Type:** All LDH **Level:** Single level L3-S1	Transforaminal endoscopic sequestrectomy (TES) Intracanal techniqu e *Sofamor-Danek endoscope*	**Follow up** 6w eeks, 0% lost to follow up **Pain leg** (VAS) pre-op.:6.7, follow up: 0.8, difference: 5.9 =88% **Pain back** (VAS) pre-op.:5.1, follow up: 1.3, difference: 3.8 =74% **PS** 77% (very satisfied + satisfied) **Complications** 5.1% **Re-operations** 10%	
Ruetten et al. 2005 [34]	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Far cranial/caudal migrated sequester Previous surgery (same level) Spinal stenosis	N=517 □277 □240 mean 38 yr range 16-78 **Type:** All LDH **Level:** Multiple level n=46 L1-L5	Extreme lateral transforaminal approach Intracanal techniqu e *Richard Wolf instrumentation* *N=27 bilateral*	**Follow up** 12 months, 10% lost to follow up **Pain leg** (VAS) pre-op.:7.1, follow up:0.8, differen ce:6.3 =89% **Pain back** (VAS) pre-op.:1.8, follow up:1.6, differen ce:0.2 =13% **Functional status** (ODI) pre-op.:78, follow up:20, differen ce:58=74% **Recurrence** 6.9% **Complications** 0% **Re-operations** 6.9%	
Sasani et al. 2007 [36]	**Inclusion criteria** Radiculopathy	N=66 □36 □30 median 52 yr	Percutaneous endoscopic discectomy (PED)	**Follow up** 12 months, 0% lost to follow up	

Study	Main inclusion criteria Main exclusion criteria	Number of participants Type / level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	Comment
	Pos tension sign Neurological deficit **Exclusion criteria** Previous surgery (same level)	range 35-73 **Type:** Foraminal + extraforaminal LDH **Level:** Single level L2-L5	Pure intradiscal technique *Karl Storz instrumentation*	**Pain** (VAS) pre-op.:8.2, follow up:1.2, difference:7.0 =85% **Functional status** (ODI) pre-op.:78, follow up:8, difference:70=90% **Complications** 6.1% **Re-operations** 7.6%	
Schubert and Hoogland 2005 [42]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit Sequestration **Exclusion criteria** Previous surgery (same level)	N=558 □179 □379 mean 44 yr range 18-65 **Type:** All LDH **Level:** Single level L2-S1	Transforaminal nucleotomy with foraminoplasty Intracanal technique *Thessys instrumentatuion*	**Follow up** 12 months, 8.7% lost to follow up **Pain leg** (VAS) pre-op.:8.4, follow up:1.0, difference:7.4 =88% **Pain back** (VAS) pre-op.:8.6, follow up:1.4, difference:7.2 =84% **GPE** (MacNab) 51% excellent, 43% good, 0.3% poor **Recurrence** 3.6% **Complications** 0.7% **Re-operations** 3.6%	
Suess 2005 [44]	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Cauda syndrome Spinal stenosis	N=25 □11 □14 mean 48 yr, range 26-72 **Type:** Foraminal + extraforaminal LDH **Level:** Single level L2-L5	Percutaneous transforaminal endoscopic sequestrectomy (PTFES) Pure intradiscal technique *instrumentation not specified*	**Follow up** 6weeks, 0% lost to follow up **Pain leg** (VAS) pre-op.:6.7, follow up:0.8, difference:5.9 =88% **Pain back** (VAS) pre-op.:5.1, follow up:1.3, difference:3.8=75% **Complications** 4% **Re-operations** 8%	All patients operated under general anaesthesia and EMG monitoring

Table 7: Retrospective cohort studies

Study	Main inclusion criteria Main exclusion criteria	Type / level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
Ahn et al. 2004 [1]	**Inclusion criteria** Prior disc surgery Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Segmental instability Spondylolisthesis Calcified fragments	N=43 □11 □32 mean 46 yr range 22-72 **Type:** All LDH **Level:** Single level L3-S1	Percutaneous endoscopic lumbar discectomy (PELD) Intradiscal & intracanal technique *instrumentation not specified*	**Follow up** range: 24-39 months, 0% non-responders **Pain** (VAS) pre-op.:8.7, follow up:2.6, difference:6.1 =70% **GPE** (MacNab) 28% excellent,53% good, 4.7% poor **Complications** 4.6% **Re-operations** 2.3%	Authors induded only patients with recurrent LDH, more than 6 months after open microdiscectomy
Chiu 2004 [2]	**Inclusion criteria** Virgin and prior disc surgery	N=2000 □990 □1010	Transforaminal microdecompressive	**Follow up** mean: 42 mos(range: 6-72), 0% non-responders	Authors induded also

Study	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
	Pain in back Radiculopathy Neurological deficit **Exclusion criteria** Cauda syndrome Painless motor deficit	mean 44 yr range 24-92 **Type:** not specified **Level:** Single and multiple level	endoscopic assisted discectomy (TFM EAD) Intradiscal & intracanal technique *Karl Storz instrumentation*	**GPE** (undear instrument) 94% excellent or good, 3%poor **Complications** 1% **Re-operations** Not specified	patients with stenosis and degenerative disc disease
Choi et al. 2007 [3]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Previous surgery (same level) Central or lateral stenosis Segmental instability Calcified disc	N=41 □23 □18 mean 59 yr range 32-74 **Type:** Extraforaminal LDH **Level:** Single level L4-S1	Extraforaminal targeted fragmentectomy Pure intradiscal technique *YESS, Richard Wolf instrumentation*	**Follow up** mean: 34 mos(range: 20-58), 4.9% non-responders **Pain leg** (VAS) pre-op.:8.6, follow up:1.9, difference:6.7 =78% **Return to work** mean: 6 weeks (range: 4-24) **Functional status** (ODI) pre-op.:66.3, follow up:11.5, difference:54.8 =83% **PS** 92% **Recurrence** 5.1% **Complications** 5.1% **Re-operations** 7.7%	
Ditsworth 1998 [4]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Spinal stenosis Segmental instability	N=110 □40 □70 median 55 yr range 20->60 **Type:** All LDH **Level:** Single level	Endoscopic transforaminal lumbar discectomy Intradiscal & intracanal technique *Flexible endoscope*	**Follow up** range: 24-48 months, 0% non-responders **GPE** (MacNab) 91% excellent or good, 4.5%poor **Recurrence** 0% **Complications** 0.9% **Re-operations** 4.5%	
Eustacchio 2002 [5]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Cauda syndrome	N=122 □36 □86 median 55 yr range 18-89 **Type:** All LDH **Level:** Multiple level n=4 L2-S1	Endoscopic percutaneous transforaminal treatment Intradiscal & intracanal technique *instrumentation not specified*	**Follow up** mean: 35 mos(range: 15-53), 0%non responders **GPE** (MacNab) 45% excellent, 27% good, 27%poor **Functional status** (PROLO) 71.9% excellent or good **Return to work** 94% **Recurrence** 12% **Complications** 9% **Re-operations** 27%	Authors excluded N=10 from analyses due to stopped procedures. These were taken into account in this review
Haag 1999 [6]	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Discus narrowing Calcified disc	N=101 **Type:** All LDH **Level:** Single level L2-S1	Transforaminal endoscopic microdiscectomy Pure intradiscal technique *Sofamor Danek instrumentation*	**Follow up** mean: 28 mos(range: 15-26), 9%non-responders **PS** good: 66%, satisfied: 9%, poor: 25% **Complications** 7.6% **Re-operations** 17%	Authors excluded N=3 from analyses due to technical problems during procedures. These were taken into account in this review

Study	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
Hochschuler 1991 [8]	**Inclusion criteria** Radiculopathy **Exclusion criteria** Previous operation (same level) Sequestration High iliac crest	N=18 □5 □13 mean 31 yr range 18-55 **Type:** not specified **Level:** L3-S1	Arthroscopic microdiscectomy (AMD) Pure intradiscal technique *Kambin technique*	**Follow up** mean: 9 mos(range: 4-13), 0% non-responders **Re-operations** 11%	
Hoogland 2003 [9]	**Inclusion criteria** Not specified **Exclusion criteria** Not specified	N=246 **Type:** not specified **Level:** Not specified	Transforaminal endoscopic discectomy with foraminoplasty Intracanal technique *Thessys instrumentation*	**Follow up** 24 mos, 0% non-responders **GPE** (MacNab) 86% excellent or good, 7.7% poor **Complications** 1.2% **Re-operations (1st year)** 3.5%	Authors included also patients with foraminal stenosis
Iprenburg 2007 [13]	**Inclusion criteria** Not specified **Exclusion criteria** Central stenosis	N=149 □62 □87 mean 43 yr range 17-82 **Type:** All LDH **Level:** Single level L3-S1	Transforaminal endoscopic surgery Intracanal technique *Thessys instrumentation*	**Follow up** not specified, 29% non-responders **Pain** (VAS) not specified **Functional status** (ODI) not specified **Recurrence** 6% **Complications** not specified **Re-operations** not specified	
Jang 2006 [14]	**Inclusion criteria** Radiculopathy **Exclusion criteria** Previous surgery (same level) Segmental instability Spinal stenosis Listhesis	N=35 □20 □15 mean 61 yr range 22-84 **Type:** Foraminal and extraforaminal LDH **Level:** Single level L2-S1	Transforaminal percutaneous endoscopic discectomy (TPED) Intradiscal & intracanal technique *instrumentation not specified*	**Follow up** mean: 18 mos(range: 10-35), 0% non-responders **Pain** (VAS) pre-op.:8.6, follow up:3.2, difference:5.4 =63% **GPE** (MacNab) 86% excellent or good, 8.6% poor **Recurrence** 0% **Complications** 17% **Re-operations** 8.6%	
Lew 2001 [26]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Previous surgery (same level)	N=47 □12 □35 mean 51 yr range 30-70 **Type:** Foraminal and extraforaminal LDH **Level:** L1-L5	Transforaminal percutaneous endoscopic discectomy Pure intradiscal technique *Surgical dynamics instrumentation*	**Follow up** mean: 18 mos(range: 4-51), 0% non-responders **GPE** (MacNab) 85% excellent or good, 11% poor **Return to work** 89% **Complications** 0% **Re-operations** 11%	
Mayer and Brock 1993 [29]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria**	N=30 □11 □19 **Type:** not specified **Level:** Multiple	Percutaneous endoscopic lumbar discectomy (PELD) Pure intradiscal technique *instrumentation not specified*	**Follow up** range: 6-18 mos, 0% non-responders **GPE** (S/S score) 67% excellent or good, 33% moderate or poor **Return to work** 7.1 ± 4.2weeks, 90%(6 months) **Complications** 3.3%	20 of the patients were described in a prospective study [30]

Study	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
	Sequestration Previous surgery (same level) Cauda syndrome Segmental instability Spinal stenosis Listhesis	level n=1 L2-L5		**Re-operations** 3.3%	In this review reoperations were labelled as moderate or poor outcome on GPE
Savitz 1994; Savitz et al. 1998 [37;38]	**Inclusion criteria** Radiculopathy Pos tension sign Neurological deficit **Exclusion criteria** Previous surgery (same level) Sequestration Obesity	N=300 □132 □168 range 16-81 yr **Type:** not specified **Level:** Multiple level n=40 L2-S1	Percutaneous lumbar discectomy with endoscope Pure intradiscal technique *Kambin technique*	**Follow up** 6mos, 0% non-responders **Return to work (6 mos)** 67% **Complications** 5.3% **Re-operations** 1.3%	
Schreiber et Suezawa 1986; Suezawa and Schreiber 1988; Leu and Schreiber 1991; Schreiber and Leu 1991 [25;40;41;45]	**Inclusion criteria** Radiculopathy **Exclusion criteria** Sequestration	N=174 □68 □106 mean 39 yr, range 16-81 **Type:** not specified **Level:** Multiple level n=25	Percutaneous nucleotomy with discoscopy Pure intradiscal technique *Modified Hijikata instrumentation biportal*	**Follow up** mean: 28 mos, 0% non-responders **GPE** (S/S score) 85% excellent or good **Complications** 10% **Re-operations** 21%	Authors induded also patients with degenerative disc disease, only the scores from LDH are quoted in this review.
Shim et al 2007 [43]	**Inclusion criteria** Radiculopathy **Exclusion criteria** Not specified	N=71 □39 □32 mean 45 yr range 21-74 **Type:** not specified **Level:** Single level T12-S1	Transforaminal endoscopic surgery Pure intradiscal technique *YESS, Richard Wolf instrumentation*	**Follow up** mean: 6 mos (range: 3-9), 0% non-responders **GPE** (MacNab) 33% excellent, 45% good, 6.5% poor **Complications** 2.8% **Re-operations** 7.0%	N=14 patients with L5-S1 level LDH are operated via a interlaminar approach
Tsou and Yeung 2002 [46]	**Inclusion criteria** Radiculopathy Neurological deficit **Exclusion criteria** Sequestration Previous operation (same level)	N= 219 □83 □136 mean 42 yr range 17-71 **Type:** Central LDH **Level:** Single level L3-S1	Transforaminal endoscopic decompression Intradiscal & intracanal technique *YESS, Richard Wolf instrumentation*	**Follow up** mean: 20 mos (range: 12-108), 11.9% non-responders **GPE** (MacNab) 91% excellent or good, 5.2% poor **Recurrence** 2.7% **Complications** 2.7% **Re-operations** 4.6%	Possible patient overlap with other study [49]
Tzaan 2007 [47]	**Inclusion criteria** Pain in leg and back **Exclusion criteria**	N=134 □56 □78 mean 38 yr range 22-71	Transforaminal percutaneous endoscopic lumbar discectomy (TPELD)	**Follow up** mean: 38 mos (range: 3-36), 0% non-responders **GPE** (modified MacNab) 28% excellent, 61% good, 3.7% poor	

Study	Main inclusion criteria Main exclusion criteria	Type/ level LDH	Interventions / Technique/ *instrumentation*	Follow up: duration and outcome	comment
	Sequestration Spinal stenosis Calcified disc Segmental instability Cauda syndrome	**Type:** All LDH **Level:** Multiple level N=20 L2-S1	Pure intradiscal technique *instrumentation not specified*	**Recurrence** 0.7% **Complications** 6.0% **Re-operations** 4.5%	
Wojcik 2004 [48] 2004	**Inclusion criteria** Radiculopathy **Exclusion criteria** Sequestration Chronic back pain	N=43 □25 □18 mean 30 yr **Type:** not specified **Level:** Not specified	Endoscopically assisted percutaneous lumbar discectomy Pure intradiscal technique *Modified Hijikata instrumentation*	**Follow up** 18 mos, 16.3% non-responders **GPE** (undear instrument) 64% good, 36% satisfied, 0% poor **Complications** not specified **Re-operations** not specified	
Yeung and Tsou 2002 [49]	**Inclusion criteria** Prior disc surgery n=31 Radiculopathy Neurological deficit **Exclusion criteria** Sequestration Central and lateral stenosis	N= 307 □102 □205 mean 42 yr range 18-72 **Type:** All LDH **Level:** Single level L2-S1	Posterolateral endoscopic excision for lumbar disc herniation Intradiscal & intracanal technique *YESS, Richard Wolf instrumentation*	**Follow up** mean: 19 mos(range: 12-?), 8.8% non-responders **GPE** (MacNab) 84% excellent or good, 9.3% poor **Recurrence** 0.7% **Complications** 3.9% **Re-operations** 4.6%	Possible patient overlap with other study [46]

Table 8: Methodological quality prospective controlled studies

Study	A	B	C	D	E	F	G	H	I	J	K	Risk of bias
Hermantin et al.1999 [7]	1	1	1	0	0	1	1	1	1	?	1	Low
Hoogland et al. 2006 [11]	0	0	1	0	0	0	0	1	1	1	1	High
Krappel et al. 2001 [21]	0	0	?	0	0	0	?	1	0	1	0	High
Lee et al. 1996 [24]	0	0	?	0	0	0	?	?	1	1	1	High
Mayer and Brock 1993 [29;30]	?	?	1	0	0	0	?	?	1	1	1	High
Ruetten et al. 2008 [35]	0	0	?	0	0	0	?	1	1	1	1	High

Table 9: Methodological quality retrospective controlled studies

Study	A	B	C	D	E	F	G	H	I	J	K	Risk of bias
Kim et al. 2007 [18]	0	0	0	0	0	0	?	?	1	0	0	High
Lee et al. 2006 [23]	0	0	1	0	0	0	0	?	1	1	0	High

Table 10: Methodological quality prospective cohort studies

Study	A	B	C	D	E	Risk of bias
Hoogland et al. 2008 [12]	1	1	0	0	1	High
Hoogland and Schenkenbach 1999 [10;39]	0	0	0	0	1	High
Kafadar et al. 2006 [15]	1	1	0	1	0	High
Kambin et al. 1998 [16;17]	0	1	0	0	1	High
Knight et al. 2001 [19;20]	1	1	0	0	1	High
Lee et al. 2007 [22]	1	1	0	0	0	High
Morgenstern et al. 2005 [31]	0	1	0	1	0	High
Ramsbacher et al. 2000 [33]	0	1	0	0	1	High
Ruetten et al. 2005 [34]	1	1	0	1	1	Low
Sasani et al. 2007 [36]	0	1	0	0	1	High
Schubert and Hoogland 2005 [42]	0	1	0	0	1	High
Suess et al. 2005 [44]	0	1	0	0	1	High

Table 11: Methodological quality retrospective cohort studies

Study	A	B	C	D	E	Quality rating
Ahn et al. 2004 [1]	0	1	0	0	1	High
Chiu 2004 [2]	1	?	0	0	0	High
Choi et al. 2007 [3]	1	1	0	0	0	High
Ditsworth 1998 [4]	1	1	0	0	1	High
Eustacchio et al. 2002 [5]	1	1	0	0	0	High
Haag 1999 [6]	0	1	0	0	0	High
Hochschuler 1991 [8]	0	1	0	0	0	High
Hoogland 2003 [9]	0	?	0	1	1	High
Iprenburg 2007 [13]	0	0	0	0	?	High
Jang et al. 2006 [14]	0	1	0	1	0	High
Lew et al. 2001 [26]	0	1	0	0	0	High
Mayer and Brock 1993 [29]	0	?	0	0	0	High
Savitz et al. 1998 [37;38]	0	?	0	0	1	High
Schreiber et al. 1991 [25;40;41;45]	0	0	0	0	0	High
Shim et al. 2007 [43]	0	1	0	0	0	High
Tsou and Yeung 2002 [46]	1	1	0	0	1	High
Tzaan 2007 [47]	0	1	0	0	0	High
Wojcik 2004 [48]	0	0	0	0	1	High
Yeung and Tsou 2002 [49]	1	0	0	0	0	High

Table 12: Overall outcome, non-controlled studies

Outcome measure (instrument)	Studies (patients)	Outcome median (min-max)
Pain leg (VAS)	7 (n=1558)	88% (65-89%) improvement
Pain back (VAS)	5 (n=1401)	74% (13-84%) improvement
Pain (region not specified)(VAS)	3 (n=144)	70% (63-85%) improvement
GPE (McNab)	15 (n=2544)	85% (72-94%) satisfactory 6% (0.3-27%) poor
Functional status (ODI)	3 (n=624)	83% (74-90%) improvement
Patient satisfaction	3 (n=181)	78% (75-92%) satisfactory
Return to work	5 (n=757)	90% (67-95%)
Recurrence	13 (n=2612)	1.7% (0-12%)
Complication	28 (n=6336)	2.8% (0-40%)
Re-operation	28 (n=4135)	7% (0-27%)

Table 13: Intradiscal and intracanal techniques, outcomes non controlled studies

Pure intradiscal technique 14 studies (n=1267)Intradiscal technique

Outcome measure (instrument)	Studies	Outcome median (min-max)
Pain leg (VAS)	2 (n=66)	83% (78-88%) improvement
Pain back (VAS)	1 (n=25)	75% improvement
Pain (region not specified) (VAS)	1 (n=66)	85% improvement
GPE (MacNab)	3 (n=279)	85% (78-89%) satisfactory 6.5% (3.7-11%) poor
Recurrence	3 (n=217)	0.7% (0-5.1%)
Complication	12 (n=1206)	5.3 % (0-40%)
Re-operation	14 (n=1267)	7.5% (1.3-30%)

Intracanal technique 16 studies (n=4985)

Outcome measure (instrument)	Studies	Outcome median (min-max)
Pain leg (VAS)	5 (n=1524)	88% (65-89%) improvement
Pain back (VAS)	4 (n=1408)	70% (13-84%) improvement
Pain (region not specified) (VAS)	2 (n=78)	67% (63-70%) improvement
GPE (MacNab)	12 (n=2292)	86% (72-93%) satisfactory 6% (0.3-9.3%) poor
Recurrence	10 (n=2395)	3.2% (0-12%)
Complication	17 (n=5362)	2.1% (0-17%)
Re-operation	15 (n=3098)	4.6% (0-27%)

Table 14: Outcomes of improvement in lateral herniations, central herniations and all types of herniations;

Type: far lateral LDH 6 studies (n=214)

Outcome measure (instrument)	Studies	Outcome median (min-max)
Pain (region not specified) (VAS)	4 (n=167)	82% (63-88%) improvement
GPE (MacNab)	2 (n=52)	86% (85-86%) satisfactory 9.8% (8.6-11%) poor
Functional status (ODI)		
Recurrence	2 (n=76)	2.6% (0-5.1%)
Complication	5 (n=214)	5.1% (0-17%)
Re-operation	5 (n=214)	8.0% (7.6-11%)

Type: central LDH 1 study (n=71)

Outcome measure (instrument)	Studies	Outcome median (min-max)
GPE (MacNab)	1 (n=71)	91% satisfactory 12% poor
Complication	1 (n=71)	2.7%
Re-operation	1 (n=71)	4.6%

Type: all LDH 15 studies (n=3067)

Outcome measure (instrument)	Studies	Outcome median (min-max)
Pain leg (VAS)	4 (n=1374)	88% (69-89%) improvement
Pain back (VAS)	4 (n=1374)	70% (13-84%) improvement
Pain (region not specified) (VAS)	1 (n=43)	70% improvement
GPE (MacNab)	9 (n=1810)	83% (79-94%) satisfactory 4.6% (0.3-9.3%) poor
Recurrence	9 (n=2201)	3.6% (0-12%)
Complication	15 (n=2934)	4.9% (0-45%)
Re-operation	15 (n=2934)	5.6% (2.3-27%)

Table 16: *outcomes of improvement of transforaminal endoscopic versus open microdiscectomy*

Endoscopic (index) vs open microdiscectomy (control),

Outcome measure (instrument)	**Studies**	**Outcome median (min-max)**
Pain leg(VAS)	1 (n=200)	**Index** 89% improvement **Control** 87% improvement
Pain back (VAS)	1 (n=200)	**Index** 42% improvement **Control** -8.3% improvement
Pain (region not specified) (VAS)	1 (n=60)	**Index** 71% improvement **Control** 82% improvement
GPE (MacNab/other)	5 (n=1102)	**Index** 84% (70-97%) satisfactory 1.7% (0-5.4%) poor **Control** 78% (65-93%) satisfactory 3.3%(0-15%) poor
Recurrences	4 (n=1182)	**Index** 5.7% (5-6.6%) **Control** 2.9% (0-6.8%)
Complications	6 (n=1302)	**Index** 1.5% (0-6.7%) **Control** 1.0% (0-12%)
Re-operations	6 (n=1302)	**Index** 6.8% (3.3-15%) **Control** 4.7 % (0-11.5%)

Abbreviations and explanatory word list:

I: index intervention
C: control intervention

LDH: Lumbar disc herniation
Type: in transversal section, subdivided in central, paramedian, foraminal and extraforaminal
herniations
Intervention: as quoted in original article
Pos tension signs: positive tension signs(straight leg raising test or controlateral straight leg
raising test)

Outcomes
S: statistically significant
NS: not statistically significant
PS: Patient Satisfaction
MacNab: MacNab score as described by MacNab[28] The sum of 'excellent' and 'good' outcomes are labelled 'satisfactory'
GPE: global perceived effect

S/S-score: Suezawa and Schreiber score [29]
Presby. St Luke score: Rush-Presbyterian-St. Luke score[16]
ODI: Oswestry disability index[27]
PROLO: Prolo functional-economic outcome rating scale[32]

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Bijlage 3 Reactie NOV

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Nijmegen, 25 juni 2008
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Geachte mevrouw Ligtenberg,

U verzocht de Nederlandse Orthopaedische Vereniging om een oordeel van de review die u opstelde over endoscopische transforaminale behandeling van een lumbale HNP.

Gaarne meld ik u dat het bestuur van de Nederlandse Orthopaedische Vereniging (NOV) op advies van de Dutch Spine Society, waarin de NOV haar werkgroep Wervelkolom heeft ondergebracht, de review en het standpunt van CVZ ondersteunt ten aanzien van endoscopische transforaminale behandeling van een lumbale HNP.

Ik vertrouw er op u met deze informatie van dienst te zijn.

Met vriendelijke groet,

Drs. C.R. van der Togt
Directeur

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Bijlage 4 Reactie DSS

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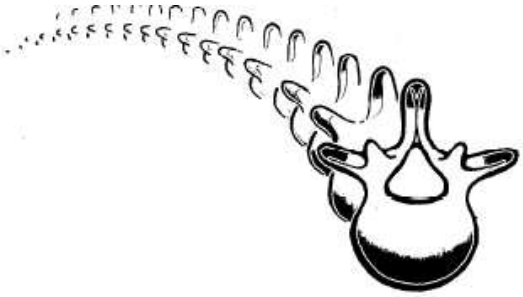

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1110 AH DIEMEN

Nijmegen, 1 juli 2008

Geachte mevrouw Ligtenberg,

In uw mail van 16 juni 2008 vraagt u het bestuur van de Dutch Spine Society (DSS) om het door het CVZ opgestelde rapport over de Percutane Transforaminale Endoscopische Discectomie (PTED) van commentaar te voorzien.

Bij het opstellen van dit rapport is reeds gebruik gemaakt van de concept versie hernieuwde richtlijn voor de behandeling van het Lumbaal Radiculair Syndroom (LRS). Deze concept versie ligt nu voor bij de diverse betrokken wetenschappelijke verenigingen ter goedkeuring.
Tevens is gebruik gemaakt van het (nog niet gepubliceerde) review artikel van Nellensteijn et al., 2008: Transforaminal endoscopic surgery for symptomatic lumbar disc herniations. A systematic review.

Bij het tot stand komen van beide referentie stukken zijn diverse (oud) bestuursleden van de DSS intensief betrokken.

Het bestuur van de DSS is van mening dat het rapport over de Percutane Transforaminale Endoscopische Discectomie (PTED) zorgvuldig is opgesteld en heeft dan ook geen op- of aanmerkingen. Het standpunt van CVZ dat de interventie niet voldoet aan het criterium zorg en er derhalve behoefte is aan goed opgezette RCT's , wordt ten zeerste ondersteund.

Me vriendelijke groet,
Namens het bestuur van de Dutch Spine Society

P.J. Schutte, secretaris