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Predictive Factors for the Outcome of Surgical Treatment of Lumbar Spondylolysis in Young Sporting Individuals

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Abstract

Study Design: Retrospective consecutive case series.

Objectives: Only few sporting individuals with symptomatic lumbar pars injuries require surgical repair and it is often difficult to predict the outcome following surgery. The factors that predict the outcome after direct repair of lumbar pars defect was evaluated clinically and statistically. The preoperative background variables both subjective and objective as well as radiological evaluation were used in a multiple regression model to find the strong predictors of postoperative outcome as measured by VAS (visual analogue scores), ODI (Oswestry Disability Index) and SF-36 (Short Form).

Methods: Fifty-two consecutive young sporting individuals with a mean age of 19 years (range 8-30 years) were treated surgically for lumbar pars defect confirmed on imaging studies (ie, single-photon emission computed tomography, computed tomography, and magnetic resonance imaging). Fifty patients completed the VAS, ODI, and SF-36 questionnaires as a part of their assessment. Preoperative background variables were used in a multiple regression model to find the strongest predictor of postoperative outcome as measured by ODI. Ethical approval was taken by the institutional review board.

Results: Buck's screw repair of the pars defect was carried out in 44 patients (33 males, 11 female): unilateral in 8 patients (7 males, 1 female) and bilateral in 36 patients (26 males, 10 females). Although age at surgery showed linear colinearity ($\rho = 0.32$, $P < .05$), it was not significant in the model. The most consistent association with the preoperative VAS score were the pre- and postoperative ODI scores, that is, $\rho = 0.51$ ($P < .01$) and $\rho = 0.33$ ($P < .05$), respectively. In the bilateral group, with Buck's repair at a single level, that is, 33 of 36 (93%) patients had returned to sports at a mean time of 7.5 months (range 6-12 months). Overall, 44 of 52 (84%) individuals had returned to their sports with posttreatment ODI score of <10. The stepwise regression modeling suggested 6 independent factors (preoperative ODI, preoperative SF-36 physical component summary (PCS), Buck's repair, multiple operations, professionalism, and pars defect at L3), as the determinants of the outcome (ie, postoperative ODI) in 80.9% patients ($R^2 = 0.809$).

Conclusions: The outcome after direct repair of pars defect in those younger than 25 years runs a predictable course. Professionalism in sports has a high impact on the outcome. Preoperative ODI and SF-36 PCS scores are significant predictors of good functional outcome. The regression equation can predict the outcome in 80.9% sporting individuals undergoing Buck's repair.

Keywords

lumbar spondylolysis, pars defect, predictive factors, Buck's fusion

Introduction

The outcome of direct repair of lumbar pars defect with instrumentation has been reported.[1-22] There is high incidence of spondylolysis in sporting population as compared with the general

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Figure 1. AP view of lumbar spine showing Buck's fusion for bilateral L5 pars defect.

population.[23,24] In 1968, Kimura[25] described the direct repair of a PI (pars interarticularis) defect without instrumentation.

Surgery for lumbar spondylolysis is indicated when symptoms persist beyond a reasonable time affecting the quality of life in young patients, particularly in sporting individuals (athletes, soccer players, gymnasts, wrestlers, weight lifters, divers, etc).

The transition zone between the end of conservative treatment and surgical repair is gray. But many athletes or young active professional sportsmen or women would like to return to their previous level of sports since they may be earning their livelihood through the sport. The rehabilitation of these symptomatic patients need a multistep stabilization program for improving core stability and strengthening the abdominal muscles.[26] Surgical decision in the individuals with persistent symptoms is based on the fact that they remain painful and radiology may show evidence of nonreactive fracture ends in the PI. A select group of active sporting individuals may be offered the surgery and in many cases, it is a surgeon-dependent decision.

The best results have been reported in young male patients with single level pars defect who were treated early with direct repair.[12] Direct repair (Buck's repair) is usually performed with a single 3.5-mm cortical screw (Figure 1).[1,2] A midline approach is used—the spinous process, lamina, and base of the transverse processes of the lytic vertebra are exposed subperiostally. The lysis is prepared by removing fibrous tissue in and around the gap. The bony elements on both sides of the lysis are decorticated to assure bony healing of the lysis after pars repair. A 3.5-mm cortex screw enters the lamina at its inferior edge, 7 to 10 mm medial to the adjacent intervertebral joint, aiming toward the pars defect, which is crossed and enters the pedicle at the level of the defect, midway between the lateral and medial border of the pedicle. Autogenous cancellous bone graft is placed into and laterally to the lysis, between the base of the transverse process and the lamina.[1]

The preoperative predictive value of many independent factors, for example, gender, young age, sports professionals, radiological criteria, pain status as measured by visual analogue score (VAS), disability measured by the Oswestry Disability Index (ODI), and quality of life as measured by Short Form–36 health questionnaire (SF-36) has not been determined.

The aim of this study was to identify the independent factors that predict a successful outcome following surgery for lumbar pars defect in young sporting individuals and to establish an outcome predictive model based on these significant independent factors.

Materials and Methods

Patients

A total of 55 consecutive patients treated operatively following confirmation by imaging studies (single-photon emission computed tomography [SPECT], computed tomography [CT], or magnetic resonance imaging [MRI] scans) as having stress fractures of the lumbar PI ranging in age from 8 to 30 years were studied. All patients attending the Back Pain Clinic completed the VAS, ODI, and SF-36 questionnaires as a part of their assessment. Three patients were nonsporting individuals and were excluded from the study. At the time of the study, these questionnaires were sent to all 52 patients, but only 50 of 52 patients responded, and 2 of 52 were not actively involved in sports.

The sporting activities were classified into 4 types depending on the major movements of the body during the sporting activity.[27] This classification was based on a small survey of sporting individuals, postgraduate research students, and teachers in sports. All the human movements involved in sports was carried out in a sporting institute in the United Kingdom. The predominant movement was recorded into 4 major groups, that is, *trunk twisting*, *kicking*, *throwing*, and *lifting*. Although all sports required multiple movements, but for this study only the predominant movement was taken into account to explain the site of stress in the lumbar region leading to spondylolysis. The inclusion criteria were that all patients should have had low back pain who had been treated conservatively for at least 6 months for a diagnosis of lumbar spondylolysis or pars defect on imaging modalities (SPECT, CT, MRI scan). Thirty patients had CT scans and 25 patients had MRI scans. Combined CT and MRI scans were available in 25 patients. All the MRI

suggestive of no disc degeneration at the level of spondylolysis. Exclusion criteria were radiological signs of spondylolisthesis or instability, previous spinal surgery, any significant radicular pain and all the patients who had improved following conservative treatment. This study was approved by Institutional Research Ethics Committee.

Measurements

Background Factors. Age, gender, height, body mass index, age at onset of low back pain, diagnosis, imaging finding, and type of sports were recorded.

Objective Variables. The level of lumbar spondylolysis or stress injury along with unilateral or bilateral involvement of the PI was recorded. The level of sporting activity (professional or nonprofessional) and return to sports following the treatment was recorded.

Subjective Variables. Pain and disability have been established outcome measures in both low back pain and nonspecific neck pain patients.[28,29] Pre- and posttreatment VAS, ODI, and SF-36 scores were recorded for each patient. The pretreatment questionnaires were completed during the first or second visit at the clinic. The study groups had their posttreatment questionnaires answered at a minimum of 2 years after treatment (answered to an unbiased observer).

Defining Successful Outcome. An athlete had to undergo the endurance test for the sports they are playing before resuming full activities.[26] Three assessment tools were used for a sporting individual to return to his or her previous level of sporting activity. The first was a subjective assessment from the patient's perspective defined as decrease in VAS score >80% from pretreatment to posttreatment stage. A moderate correlation was found between VAS and functional capacity of athletes (change of VAS by 80%, $r = 0.52$, $P < .005$).[30] This moderate correlation may be due to the fact that the percentage improvement may not be equated for all since some may have a higher grade of pain initially. Therefore, the change is much higher if someone improves from VAS = 7 to VAS = 1 than some who improves from VAS = 4 to VAS = 0.

A second assessment was objective and clinical based. The objective assessment was carried out using ODI and SF-36 scores. The ODI was focused on physical activities and not the psychological consequences of acute or chronic pain. Self-reported disability scores, for example, ODI, have become, in their own right, a dimension of disability.[31] The items in ODI are pain intensity, personal care, ability to lift, walk, sit, stand, sleep, sex life, social life, and traveling. Normal function is 0 and the worst disability for each item is 5. The sum of the 10 "items" multiplied by 2 constitutes the ODI (0-100). It is believed that the absolute values of these scores are not necessarily comparable between patients, because different people interpret their conditions differently. However, it is assumed that they will do so to a similar degree on each occasion they complete the questionnaires, and thus the percentage change may be a more comparable guide between patients. This was borne out by the higher correlations found when the percentage change was examined.[32] Return to sport requires the individual to have no or minimal disability, therefore to reach a realistic target one needs to score below 10 in ODI at the final follow-up to be able to return to sports.

A third definition of success was return to sport for the sporting group at their previous level of sports.

Statistical Analysis

Descriptive analysis was carried out following normality curves for the study sample. Frequency distribution for each variable was recorded and tabulated. Multiple hypotheses testing was performed using the statistical software SPSS (version 20). To include age as the predictor variable in the regression model it was made into an ordinal variable by making 5 groups, namely (1) 8-14 years, (2) 15-19 years, (3) 20-24 years, (4) 25-29 years, and (5) $\geq$30 years.

Correlations between the possible prognostic factors and postoperative current pain, ODI and SF-36, at the last follow-up, were determined by Spearman rank correlation coefficient analysis. All factors with $P < .01$ were selected for further analysis. The crude association between the outcome variable (postoperative ODI) and each factor that was correlated with the outcome, was studied by univariate linear regression. This was followed by a stepwise regression procedure to reveal the important predicting factors for a good outcome. Postoperative ODI was taken as the dependent variable for the analysis for 2 reasons: (1) Independent-sample t test between unilateral and bilateral group suggested postoperative ODI to be the most significant variable determining the difference between the 2 groups and (2) ODI scores have more consistency and test-retest reliability is very high. For the regression model, adjusted R^2, β, b-value, and standard error b were used. The adjusted R^2 is the proportion of variation in the dependent variable that is explained by the independent variables, adjusted for number of variables assigned in the analysis. R^2 can also be interpreted as the proportionate reduction in error in estimating the dependent when knowing the independents. *The null hypothesis for this study was that the regression coefficient was zero for the predicted variables in surgically treated patients*. The β value is the standardized regression coefficient, which explains which independent variables are most important in predicting the dependent variable. It is calculated as if all of the independent variables had means of 0 and variance of 1.

Results

Descriptive Analysis

The mean age of onset of back pain was 18.3 years. Although age at surgery showed linear colinearity ($\rho = 0.32$, $P < .05$), it was not significant to be included in the model.

Table 1. Patient Demographics.

Factors	Unilateral	Bilateral	Combined
No. of patients	8	47	55
Male:Female	7:1	33:14	40:15
Age of onset, y, mean (range)	19.2 (15-30)	18.5 (8-30)	18.3 (8-30)
Sporting	8	44	52
Level of sporting activity, total (male:female)			
Professional	4 (4:0)	23 (18:5)	27 (22:5)
Semiprofessional	4 (3:1)	10 (8:2)	14 (11:3)
Nonprofessional	0	7 (5:2)	7 (5:2)
None	0	4 (2:2)	4 (2:2)
Length of treatment, months, mean (range)	6.5 (6-9)	7.5 (6-12)	7.3 (6-14)

Table 2. Number of Patients in Each Type of Sports.

Gender	Laterality	Throwing	Trunk Twisting	Kicking	Total
Male	Unilateral	1	3	4	8
	Bilateral	1	10	19	30
	Total	2	13	23	38
Female	Unilateral	0	1	0	1
	Bilateral	0	10	3	13
	Total	0	11	3	14

The male:female (M:F) ratio was 2.6:1 (73% male) (Table 1). A total of 52 of 55 (94%) subjects were involved in sports of which most common sport was football (soccer) (n = 22) followed by cricket (n = 8), gymnastics (n = 3), swimming (n = 3), athletics (n = 3), tennis (n = 3), and others (n = 10). In all, 27 of 52 (52%) were professional players, 14 of 52 (27%) were semiprofessional, and 7 of 52 (13.5%) were amateur sportsmen and women (Table 1). The number of patients participating in *kicking* sports was 26 of 52 (50%) and *throwing and trunk twisting* sports were 2 of 52 (3.8%) and 24 of 52 (46.2%), respectively (Table 2). The mean duration of symptoms before surgery was 6 months. The lumbar levels were 43 of 52 (78%) at L5, 3 of 52 (5.5%) at L4, and 4 of 52 (7.2%) at L3. Multiple level involvements were observed in 2 of 52 (4%) patients. One of the multiple level pars injuries had combined unilateral pars lesion at a higher lumbar level, that is, L3 and bilateral pars lesion at L5 (Table 3). Modified Buck's screw repair of the pars defect was carried out in 44 patients (33M:11 F). Unilateral repair was performed in 8 patients (7M:1F) and bilateral repair was performed in 36 patients (26M:10F) (Table 4).

Outcome of Surgery

The mean pre- and post-treatment VAS scores were 6.6 (SD = 0.97) and 0.8 (SD = 1.12), respectively ($P < .01$). The mean pretreatment ODI was 37.6 (SD = 10.5) and the mean posttreatment ODI was 9.2 (SD = 13.4) ($P < .01$). In the SF-36 scores, the mean score for the physical component of health improved from 32.7 (SD = 7.1) to 50.1 (SD = 8.8) ($P < .001$).

Table 3. Levels of Lumbar Pars Defect.

Site	L5	L4	L3	Multilevel
Unilateral	5	1	2	0
Bilateral	38	2	2	1
Uni + bilateral	0	0	0	1
Total	43	3	4	2

Table 4. Number of Surgical Repairs Performed in Unilateral or Bilateral Pars Defects.

	Male		Female		
Surgical Treatment	Unilateral	Bilateral	Unilateral	Bilateral	Total
Buck's direct repair	7	26	1	10	44
Scotts repair	0	1	0	2	3
Alar transverse repair	0	1	0	1	2
Posterolateral fusion	0	1	0	0	1
Multiple surgeries	0	0	0	1	1
Exposed but healed pars	0	0	0	1	1
Total	7	29	1	15	52

Table 5. Scores at Which Patients Returned to Active Sports After Surgery.

Scores	Unilateral (7)	Bilateral (30)
Posttreatment ODI	0-12	0-14
Posttreatment PF	36.2-57.1	46.7-57.1
Posttreatment BP	38.9-62.7	39-62.7

Abbreviations: ODI, Oswestry Disability Index; PF, physical functioning; BP, bodily function.

The mean score for the mental component of health improved from 42.8 (SD = 8.4) to 54.4 (SD = 8.2) ($P < .001$). There was significant improvement in all components of the SF-36 scores.

In the unilateral group with Buck's repair, 7 of 8 (87%) patients had complete relief of pain at a mean time of 6.5 months (range 6-9 months) following surgery. In the bilateral group, with Buck's repair at a single level, that is 33 of 36 (93%) patients had complete pain relief at a mean time of 7.5 months (range 6-12 months). Overall, 44 of 52 (84%) individuals had returned to their sports. In the bilateral pars defect group, there were 19 footballers at various levels. Of these 14 returned to the same level at which they had been competing before the onset of their symptoms. All the sporting individuals who returned to sports had their posttreatment ODI score of <10 (Table 5).

Correlation Testing

The most consistent association with the preoperative VAS score are the postoperative VAS, that is, $\rho = 0.53$ ($P < .01$) followed by pre- and postoperative ODI scores, that is, $\rho =$

Table 6. Multiple Variable Selection by Stepwise Regression Modeling.

Model	R^2	Adjusted R^2	Variable Names
1	0.685	0.678	Pre ODI
2	0.756	0.744	Pre ODI, Buck's
3	0.815	0.801	Pre ODI, Buck's, Preop SF-36pcs
4	0.846	0.830	Pre ODI, Buck's, Preop SF-36pcs, Professional
6	0.913	0.809	Pre ODI, preop SF36pcs, Buck's, professional, multiple opns, L3 pars defect

Abbreviations: ODI, Oswestry Disability Index; preop, preoperative; SF-36, 36-item Short Form health questionnaire; pcs, physical component summary; opns, operations.

Table 7. Summary of Final Regression Model.

Model	R	R^2	Adjusted R^2	Standard Error of the Estimate
1	0.913[a]	0.833	0.809	6.151

[a]Predictors: preop ODI, preop SF36pcs, professional, Buck's repair, multiple opns, L3 pars defect. Dependent variable: postop ODI.

0.51 ($P < .01$) and $\rho = 0.33$ ($P < .05$), respectively (ρ = Spearman correlation coefficient). VAS scoring is a subjective scoring and therefore postoperative ODI was taken as the final outcome score.

Regression Model

Multiple Correlations. For multiple linear regression models to predict a successful outcome where success was defined as a dichotomous outcome, one requires at least 5 cases per independent variable, which is generally considered acceptable for a small database. Entry and exit criteria into the model were set using type I error rate of 0.05 and power of 0.8. Therefore, a surgical study group consisting of 55 patients could allow for a maximum of 11 independent variables that can be inserted into the stepwise regression model. In the analysis, when the regression modeling was completed the independent variables included were (preoperative ODI, preoperative SF-36 physical component summary [PCS], Buck's repair, multiple operations, professionalism, and pars defect at L3), the adjusted R^2 was 0.809. This indicated that the regression model is a good predictor (80.9%) of the outcome variable, that is, postoperative ODI (Table 6). The final regression model used shows a good fit and predicted values were more accurate with $P < .001$ (Table 7).

The intercept or value of c in the modeling was 30.121 (CI = 11.197-49.045) (Table 8). This indicates that the independent variables that are selected by the regression model have significant effect on the postoperative ODI. A lower confidence interval for each predictor variable also suggests that these independent variables when put in the regression equation will allow a significant change in the outcome of each patient

Table 8. Final Regression Equation.

Independent Variable	Regression Coefficient (B)	Standardized Coefficient	95% Confidence Interval Regression Coefficient		P
			Lower Bound	Upper Bound	
Intercept	30.121	—	11.197	49.045	.003
Preop ODI	0.327	0.256	0.087	0.567	.009
Preop SF-36pcs	−0.581	−0.298	−0.866	−0.295	.000
Buck's repair	−11.872	−0.315	−17.727	−6.018	.000
Multiple opns	26.503	0.269	11.622	41.385	.001
Professional	−6.792	−0.220	−10.960	−2.624	.002
L3 pars defect	21.034	0.213	6.408	35.660	.006

Abbreviations: ODI, Oswestry Disability Index; preop, preoperative; SF-36, 36-item Short Form health questionnaire; pcs, physical component summary; opns, operations.

(recorded as ODI). The negative values of preoperative SF 36, Buck's repair, and professionalism means that these variables are protective for the patient. If physical conditioning is good and the individual is a professional who has a Buck's repair, then he or she will have a good outcome, that is, postoperative ODI score. The regression coefficients between all the parameters confirmed the fundamental influence on the postoperative outcome in lumbar spondylolysis. The close relationship between the outcome variable and the independent predictor variables was obvious with values of the regression coefficients.

Multivariate Analysis

The types of sports as per the predominant movement were taken into account in a regression modeling but no significant values were achieved. The negative values of preoperative SF-36, Buck's repair, and professional means that these variables are protective for the patient. If physical conditioning is good and the individual is professional who undergoes Buck's repair, then he or she will have a good outcome, that is, low postoperative ODI score.

Regression Model. The multiple linear equation for predicting postoperative ODI scores was recorded as:

$$\text{Postoperative ODI score} = 30.121 + (0.327 \times \text{preoperative ODI score}) + (-0.581 \times \text{preoperative SF-36 PCS score}) + (-11.872 \times \text{Buck's repair}) + (26.503 \times \text{Multiple operation}) + (-6.792 \times \text{professional}) + (21.034 \times \text{L3 pars defect}).$$

Buck's repair, professionalism, multiple operation, and L3 pars defect are scored as 1 and if none of these are positive they are scored as 0. Thus, for example having a professional with a preoperative ODI score of 26 and preoperative SF-36 PCS

score of 34 and having a Buck's repair and a L4 lumbar level is predicted to have a postoperative ODI score as follows:

$$Y(\text{Buck's}) = 30.121 + (0.327 \times 26) + (-0.581 \times 34) + (-11.872 \times 1) + (26.503 \times 0) + (-6.792 \times 1) + (21.034 \times 0)$$

$$Y(\text{Buck's}) = 30.121 + 8.502 - 19.754 - 11.872 - 6.792$$

$$Y(\text{Buck's}) = 38.623 - 38.418 = 0.215$$

Thus, the postoperative ODI score can be predicted in this individual as <1 when he has a Buck's repair. But if the same individual had any other surgery instead of Buck's repair of the defect then the equation would be:

$$Y(\text{Other}) = 30.121 + 8.502 - 19.754 - 6.792$$

$$Y(\text{Other}) = 12.077$$

This estimation of postoperative ODI can be successfully predicted in 95% (CI = −2.00 to +6.00).

Discussion

The goal of the pars defect reconstruction is to obtain the consolidation of the isthmus, to restore the anatomy and the stability of the spine, and to preserve the mobility of the level concerned. Roca et al[33] reported successful outcome in 13 of 15 patients who returned to their respective sports. Wu et al[34] had direct repair in 93 patients with a mean age of 23years and reported success rate of 91.3%. Buck's fusion has been used for treatment of 10 fast bowlers by Hardcastle et al[16] in Australia. Debnath and Freeman[12] from the United Kingdom reported the clinical outcome of 19 athletes who underwent direct repair of the defect with screw fixation. ODI and SF-36 scores were used to evaluate the final outcome. The mean scores improved significantly in all domains of SF-36 health questionnaire ($P < .001$). All but 1 patient had returned to active sporting life within 7 months of surgery.

There are multiple factors that may directly or indirectly influence the decision regarding the surgical repair of the defect. For a good outcome following surgery, that is, reduction in pain intensity and improvement in ODI may be predicted if all these factors were taken into consideration.

In this study, the regression coefficients between all the parameters confirmed the fundamental influence on the postoperative outcome.

Age

All patients who did well in this study were younger than 25 years. Age was included as one of the predictor variables in the linear regression model by making it an ordinal variable (making 5 groups). Although age at surgery showed a low colinearity, it was not significant enough to be included in the regression model. It seems reasonable to recommend surgical repair in patients in younger age group, that is, below the age of 25 years in whom pars defect has been identified as the sole source of pain.

Gender

There was no difference between the 2 genders in the outcome scores except for pre- and postoperative ODI. There is a possibility that the disability is perceived more by women than men with the same level of pars defect.

Professional Versus Nonprofessional

Forty-one individuals in this study were professional or semiprofessional sportspersons. The regression model selected this predictor variable for a significant functional outcome. The mathematical number derived for the slope is negative, which means that this number is subtracted from the total ODI to predict the outcome (ie, a lower ODI if professional). Therefore, professional sporting individuals have more chance of having a successful outcome than a non-professional individual. In real life, professionalism influences the individual to choose surgical repair instead of waiting and loosing valuable time and finances. Also, economic issues should be taken into account when dealing with highly active professional young ones who would do well with surgical repair early in the course of the treatment.

Unilateral Versus Bilateral

The unilateral lumbar pars defect has higher healing potential than bilateral pars defects in their terminal stage.[18] Unilateral spondylolysis predisposes the contralateral side to stress fracture, especially in athletes actively engaged in sporting activities involving trunk twisting movement.[35] In this series, unilateral group (n = 8) who had Buck's repair had a better outcome than the bilateral pars defect group (n = 36). But laterality was rejected in the linear regression modeling.

Lumbar Levels

Since 80% of the pars defect was at L5 level (unilateral or bilateral), L5 pars defect may be associated with more complications following surgical repair of the defect, that is, nonunion or remain symptomatic. This is due to the fact that L5 being the transitional vertebrum, the load at the pars at L5 exceeds than the others at level above. The proportion of union of defects at L4 was significantly higher than at L5. Fuji et al[36] concluded that the likelihood of union of the progressive defects at L5 was less than 5%. But the regression model did not suggest either L4 or L5 level to have any significant effect on the final outcome.

Although the regression model has suggested L3 lumbar level to be a significant negative predictor of final outcome, the clinical judgment is dependent on multiple factors. Of the 3 patients, only 1 had Buck's repair who had successful outcome. Two out of 3 failures at the same segment is recognized mathematically as a poor prognostic factor. Thus, it may be prudent to give advice regarding the outcome based on one successful repair with Buck's technique.

Outcome Scores

Combining all the outcome measures would allow one to understand the pain status, functional disability, motivation and physical abilities, as well as the sporting abilities. In the regression modeling, preoperative SF-36 PCS score was recorded as a significant predictor. Therefore, preoperative scores similar to the study group would give one an indication for surgical intervention.

Outcome of Buck's Direct Repair

The short-term outcome following surgery has been excellent in both unilateral and bilateral spondylolysis patients. In total, 34 of 38 (87%) patients who had Buck's repair had an excellent or good outcome. Buck's fusion stabilizes the spondylolytic segment and restores the biomechanics around the motion segment.[37] This restoration of biomechanics may enable a professional sporting individual to return to previous active level of sporting. The current study supports the views of previous authors with a mathematical model based on regression analysis which could help the surgeon to predict the outcome at the time of initial assessment.

Predicting Postoperative Outcome

The outcome predictive equation was finally based on 6 main discriminates: preoperative ODI, preoperative SF-36 PCS, Buck's repair, professional sporting individual, multiple operations, and spondylolytic level at L3. The precision of the predicted postoperative ODI scoring with the 4-item model may be more reliable than the 6-item model since the last 2 discriminates are insignificant. The final outcome may be predicted by the equation in 80.9% patients. The surgical repair should be offered to the select group of individuals who are active and young with a high motivation for sports and whose pain has not been controlled after 6 months of nonoperative treatment.

Strength

This study includes a mix of qualitative and quantitative techniques of analysis and the inclusion criteria were strictly followed. The number of cases was just adequate to apply the statistical tests. A well-defined patient population is required to reduce variability. This study has a large representative sample of sporting individuals. The postoperative outcome based on ODI is valid to predict since it determines pain and disability. The final outcome of returning to sports reduces the selection bias and recall bias.

Limitations

It was a retrospective study of a relatively uncommon diagnosis in the general population. There may have been a selection bias for performing Buck's repair in this demanding group of active sporting individuals. There may be recall bias for the patients who answered the questionnaires at different times after surgery. The interaction between the risk factors and taking the effect modifiers into account all at once are difficult in small population samples.

Conclusion

The outcome following direct repair of pars defect below the age of 25 years runs a predictable course. There is no difference in the functional outcome between the 2 genders. Professionalism in sports has a high impact on the outcome of an individual following surgical repair of the defect. Patients with unilateral spondylolysis do slightly better than bilateral spondylolysis following Buck's repair. Preoperative ODI and SF-36 PCS scores are significant predictors of a good functional outcome. The predictive model presented above could predict the outcome in 80.9% sporting individuals undergoing Buck's repair.

Declaration of Conflicting Interests

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