Clinical Study

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Functional outcomes of microdiscectomy in Bertolotti syndrome: the relationship between lumbosacral transitional vertebrae and lumbar disc herniation: a prospective study in Greece

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Study Design: The lumbosacral transitional vertebrae (LSTV) in patients with Bertolotti syndrome (BS) cause alterations in the biomechanics of the lumbosacral junction. These entities have been associated with secondary conditions, such as lumbar disc herniation (LDH).
Purpose: To investigate the clinical outcomes of microdiscectomy in patients with symptomatic LDH and BS.
Overview of Literature: There is limited data in the literature on the functional outcomes of patients with LSTV who undergo microdiscectomy.
Methods: This study enrolled 308 patients diagnosed with LDH and concurrent LSTV. All patients underwent microdiscectomy. Clinical evaluation was performed preoperatively and at distinct follow-up intervals of 1, 3, 6, and 12 months, and 2 and 5 years postoperatively. Assessment included clinical examination and implementation of the well-established, patient-reported outcome measures Visual Analog Scale (VAS) and Short-Form 36 (SF-36) Medical Health Survey Questionnaire for Health-Related Quality of Life (HRQoL) analysis. Furthermore, the anatomical relationship between LSTV and LDH was also studied.
Results: The SF-36 indices and VAS score were statistically significantly ameliorated within the follow-up period. Maximum improvement was noted at 3 months, with further minimal improvement after 6 months, and stabilization of indices until the end of follow-up. Castellvi type IB was the most frequent LSTV type. The adjacent level (L4–L5) just above the LSTV was the most affected with an incidence of 72.1%. In the subgroups of Castellvi type IA, IIA, and IIIA, the LDH side was ipsilateral with the LSTV in 38.3% of patients. In this study, all patients underwent microdiscectomy and demonstrated favorable clinical outcomes (functional recovery and pain relief) and notable amelioration of HRQoL.
Conclusions: To the best of our knowledge, this is the first study to conduct a holistic assessment in an attempt to delineate the impact of LSTV presence on the postoperative HRQoL of these individuals.

Keywords: Radiculopathies; Intervertebral disc; Discectomy; Quality of life; Lumbosacral region

Introduction

In 1917, Mario Bertolotti described an anatomical variant of the lumbosacral junction which was referred to as an abnormally enlarged transverse process of the most caudal lumbar vertebrae [1]. This "mega" apophysis was articulated or fused unilaterally or bilaterally with the sacrum base, leading to sacralization of the L5

vertebra or lumbarization of the S1 vertebra [2]. The combination of the lumbosacral transitional vertebrae (LSTV) and low back pain (LBP) (or sciatica) was termed "Bertolotti syndrome" (BS) [2].

Epidemiologic studies have shown that the incidence of individuals with asymptomatic LSTV accounts for 13% of the general population [3]. A combination of clinical evaluation and imaging findings is necessary for the diagnosis of BS. The initial treatment of BS is usually conservative, including a pharmaceutical regimen, physical therapy sessions, and abstention from intense daily activities [4]. However, patients who do not respond to these conservative measures are eligible for surgical intervention. If pseudo articulation has been identified as the primary cause of pain, then resection of the LSTV, either unilaterally or bilaterally, may be the first surgical option [4]. Moreover, spinal fusion may be necessary in cases of L5–S1 segmental instability [4].

The impact of LSTV on intervertebral disc degeneration has been noted in several studies [5-8]. However, there is a paucity of published studies investigating the functional outcomes of patients with LSTV who underwent microdiscectomy due to symptomatic lumbar disc herniation (LDH), a pathology frequently encountered in these individuals which often requires surgical management [9]. Furthermore, these studies did not include a multifaceted analysis of the functional status of affected patients. The aim of this study was to retrospectively evaluate the clinical outcomes of microdiscectomy in patients with symptomatic LDH as part of BS. To the best of our knowledge, this is the first study to conduct a holistic assessment in an attempt to delineate the impact of LSTV on the postoperative Health-Related Quality of Life (HRQoL) of these individuals.

Materials and Methods

Population and approvals

All patients enrolled in this study were diagnosed with BS using clinical (LBP and sciatica) and radiologic (LSTV and LDH) criteria and fulfilled the current indications for discectomy. The same senior spine surgeon performed all procedures in the same tertiary center. Each patient gave written consent to participate after being informed of the purpose and design of the study, and each patient's rights and privacy were protected during the conduct of the study. The study protocol was thoroughly evaluated and approved by the institutional review board of the InterBalkan European Medical Center (approval no., 1712/13.04.2022). This study refers to patients who were a subgroup of all patients treated with this protocol at the involved hospital. This study's conduct was consistent with the ethical principles for medical research involving human subjects as defined in the Declaration of Helsinki of 1964 and its later amendments (2013).

Inclusion-exclusion criteria

Inclusion and exclusion criteria are presented in Table 1.

Methods

Three hundred and eight patients were enrolled in this study and underwent microdiscectomy from 2015–2018. The preoperative neurological status was evaluated in all patients. LDH was confirmed by magnetic resonance imaging (MRI), and the LSTV type (based on the Castellvi classification system) was diagnosed by X-ray. Computed tomography (CT) was used in cases where there was a doubt about the type of LSTV on plain radiographs. Clinical assessment was carried out prior to surgery and at follow-up intervals of 1, 3, 6, and 12 months, and 2 and 5 years postoperatively. Assessment included clinical examination and implementation of the well-established patient-reported outcome measures Visual Analog Scale (VAS) and Short-Form 36 (SF-36) Medical Health Survey Questionnaire, for HRQoL analysis. Every follow-up assessment included an evaluation in the tertiary center's outpatient clinic. In rare cases, where patients lived in remote areas, follow-up was conducted via telephone.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
LBP and sciatica with LSTV and LDH, resistant to conservative measures	Spine tumor, infection, or trauma
Single level LDH (L4–L5, L5–S1)	Migrating LDH (migrated disc fragments with ascending or descending course)
Presence of neurologic deficit referrable to LDH	Spinal deformity
Hernia confirmed by MRI of the lumbar spine (compliance with clinical findings)	Presence of clinical or radiologic signs of segmental instability
Positive nerve root tension sign	Previous surgery in the affected level

LBP, low back pain; LSTV, lumbosacral transitional vertebrae; LDH, lumbar disc herniation; MRI, magnetic resonance imaging.

Surgical technique

For surgical planning, MRI and plain radiographs were part of the preoperative radiological evaluation of all patients. Patients were placed in the prone, neutral position on a Jackson table under general anesthesia. Fluoroscopic navigation (C-arm) with both lateral and anteroposterior views was used to determine the level of operation. The standard posterior technique was used which included skin incision, subcutaneous tissue dissection, and unilateral, subperiosteal dissection of the paravertebral musculature on the side of the LDH [10]. Microdiscectomy with laminectomy-flavectomy and foraminotomy was performed in all cases. Wound closure was routinely performed by layers. Each patient's neurological status was assessed immediately after surgery, and they were then kept in the monitoring chamber for half an hour before returning to the ward. Subsequently, they were mobilized with a lumbar orthosis on the day of surgery.

Visual Analog Scale

VAS is a simple, illustrative method for evaluating LBP and sciatica. A horizontal line of 100 mm was utilized in this study. Patients were asked to indicate their subjective perception of pain with a mark. The level of minimally clinically significant change was designated as 9 mm. Other parameters including sex, age, and etiology of pain were not considered separately [11].

SF-36 Medical Health Survey Questionnaire

The SF-36 Medical Health Survey Questionnaire is a widely used method for the evaluation of HRQoL after spine surgery [12]. This questionnaire consists of 36 items evaluating eight parameters reflecting the patients' general health: physical function, role physical, bodily pain, general health, energy, fatigue and vitality, social function, role emotional, and mental health. Each patient was asked to complete the questionnaire at each follow-up visit. Following the collection of all replies, percentage scales were created. A higher score is typically linked to improved HRQoL. If less than half of the responses to a questionnaire were completed, it was deemed invalid [12].

Statistical analysis

Statistical analysis of the data was conducted with the statistical package Jamovi ver. 2.3 computer software (https://www.jamovi.org/) [13]. Continuous variables were expressed as mean±standard deviation, and categorical variables were expressed as percentages. Normality of data was tested with the Shapiro-Wilk test. Paired-samples *t*-test or Wilcoxon signed-rank test were implemented for statistical comparison of data among the various follow-up assessments for the presence or absence of normality, respectively. A *p*-value of 0.05 was used as the threshold for statistical significance.

Results

A total of 308 patients were included in the present study. The demographic characteristics of the individuals are noted in Table 2. All patients were subjected to uneventful microdiscectomy, were mobilized on the day of surgery, and were discharged within ten hours postoperatively.

Severe perioperative complications including major intraoperative hemorrhage, nerve tissue damage, or dural tear were not observed. Wound infection occurred in nine patients (2.9%) and was successfully managed with oral antibiotics without further complications. All patients were routinely evaluated at predetermined follow-up intervals, and all successfully completed the 5-year follow-up.

The most common type of LSTV, according to the Castellvi classification system, was type IB. This occurred in 19.2% of patients, while the least common complication was IIIA at 7.1%. Overall, type I was observed in 29.6%, type II in 33.1%, type III in 22.4%, and

Table 2. Demographics of patients and characteristics of LSTV and LDH

Characteristic	Value
Demographics features of patients	
No. of patients	308
Mean age (yr)	35.7±10.8
Median age (yr)	36.5 (18–53)
Male	172 (55.8)
Female	136 (44.2)
Relationship between LSTV and level of LDH	
Adjacent level (L4–L5)	222 (72.1)
Same level with LSTV	86 (27.9)
Side of LSTV and LDH (subgroup of 99 patients)	
Contralateral	61 (61.7)
Ipsilateral	38 (38.3)

Values are presented as number (%), mean±standard deviation, or median (min–max).
LSTV, lumbosacral transitional vertebrae; LDH, lumbar disc herniation.

Table 3. Types of LSTV according to the Castellvi classification system

Type of LSTV	No. (% of total)
IA	32 (10.4)
IB	59 (19.2)
IIA	45 (14.6)
IIB	57 (18.5)
IIIA	22 (7.1)
IIIB	47 (15.3)
IV	46 (14.9)

LSTV, lumbosacral transitional vertebrae.

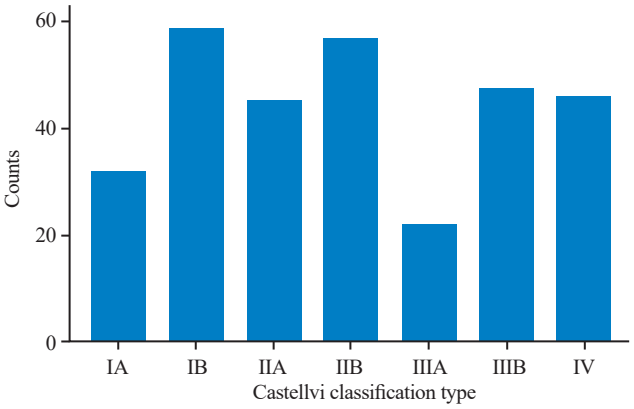

Fig. 1. The diagram presents the type of lumbosacral transitional vertebrae in our study population.

type IV in 14.9% of affected individuals (Table 3, Fig. 1).

The relationship between the presence of LSTV and the level of LDH was also evaluated. In the majority of patients, the adjacent level (L4–L5) just above the LSTV was the most affected. In contrast, 88 patients (27.9%) presented with LDH at the same level (L5–S1) as LSTV (Table 2). We also investigated the side of LDH in patients with LSTV types IA, IIA, and IIIA (contralateral or ipsilateral). In this subgroup of 99 patients, the side of LDH was contralateral to the side of LSTV in 61 patients (61.7%) (Table 2).

All preoperative indices of SF-36 and VAS scores are presented in Table 4. After surgery, all examined VAS scores and SF-36 indices showed a considerable, and statistically significant, improvement during the first 3 months postoperatively, with a less noticeable improvement over the following 3 months. After 6 months, stabilization and minimal alteration of recorded values was observed until the end of follow-up (Fig. 2). Although there was comparatively less progress after the 6-month interval, statistical analysis showed that, compared to the prior interval, every follow-up evaluation for all analyzed indicators showed statistically significant improvements (Table 5).

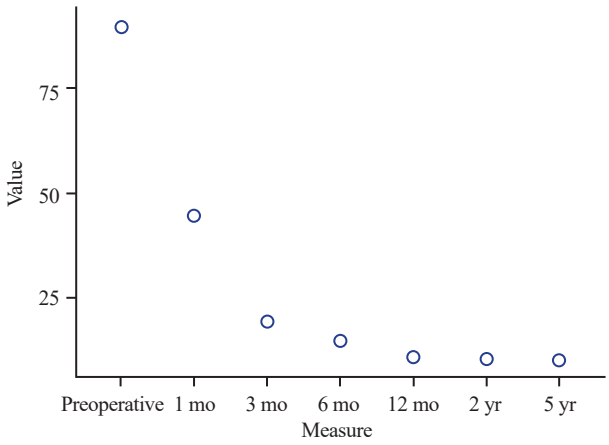

Fig. 2. The points mention the alteration of Visual Analog Scale score during various follow-up.

Table 4. Preoperative indices of SF-36 and VAS score

	Mean±SD	Shapiro-Wilk *p*-value
VAS	89.5±8.45	<0.001
SF-36		
Physical functioning	34.4±3.49	<0.001
Role functioning	33.7±3.37	<0.001
Bodily pain	30.1±1.39	<0.001
General health	30.1±3.30	<0.001
Vitality	30.4±2.36	<0.001
Social functioning	30.6±1.70	<0.001
Role emotional	31.9±1.42	<0.001
Mental health	33.6±1.73	<0.001

SF-36, Short-Form 36; VAS, Visual Analog Scale; SD, standard deviation.

Discussion

The incidence of LSTV in the general population is reported to be between 4%–36%, and it presents with either sacralization of L5 (7.5%) or lumbarization of S1 (5.5%) [4,14]. BS is encountered in 4%–8% of patients with LBP [4]. In 1984, Castellvi classified the presentation of LSTV into four types according to the degree of articulation or fusion and occurring either unilaterally or bilaterally (subtypes a and b) (Table 6) [15]. In a study of 841 patients published by Nardo et al. [16], type I (41.7%) was the most common LSTV type, while type IV was the rarest (5.2%). Although type I is the most common, the other three types are more likely to cause LBP warranting intervention [16]. In this study, the most common type of LSTV was Castellvi type IB, affecting 19.2% of the patients. This is similar to previous studies which found type IB to be the most frequent type of LSVT. Noorman et al. [17] reported Castellvi

type I to be most frequent (43.8%). Age and sex have also been considered as determinants of intervertebral disc degeneration in patients with LSTV [4,5]. Among young men, LSTV was linked to disc degeneration in the intervertebral disc above it, while among middle-aged men, it was associated with a lower prevalence of disc degeneration in the intervertebral disc below it [8]. Bron et al. [18] mentioned a relationship with early disc degeneration above LSTV in young patients. Overall, men have a higher incidence of LSTV than women [19]. In a study by Ucar et al. [19] involving 683 patients with LSTV, a gender distribution of 369 men (54%) and 314 women (46%) was reported. In this study, types Ia (16.5%) and Ib (12.9%) were statistically significantly greater in men, and sacralization was more common in men, while lumbarization was more common in women [19]. Fidan et al. [6] reported that LDH is more common in the presence of LSTV, and female sex is highly associated with disc herniation.

BS describes a clinical entity of LBP in the presence of a lumbosacral pseudo articulation [2]. The pathogenesis and precise etiology of BS are not well understood which has resulted in inconsistent diagnosis and therapy. Clinical presentation refers to LBP, buttock pain, and S1 radiculopathy [20]. Plain radiographs (anteroposterior and lateral views) or CT scan can demonstrate the type of LSTV according to the Castellvi classification system [1]. A suggested 30° angled anteroposterior (Ferguson view) radiograph can improve diagnostic accuracy [4]. MRI is useful for providing information about intervertebral disc and nerve root pathologies. The accuracy of MRI is more than 80% in the diagnosis of BS [21].

In addition, the presence of LSTV modifies the biomechanical characteristics of the lumbosacral junction, causing secondary pathological spinal conditions such as facet joint arthritis, LDH, and spinal-foraminal or extraforaminal stenosis [20]. In particular, the presence of LSTV leads to balance problems due to abnormal compressive loads, muscle strain, and joint overload of the sacroiliac joint. LBP is a consequence of discrepancies in spine motion and loading. LSTV alters the normal spinal curvature and provokes asymmetric loading and wear on the facet joints (pseudo articulation) which can contribute to degenerative alterations adjacent to the LSTV segments [22]. According to the affected level (L5–S1), Jancuska et al. [2] emphasized that the presence of LSTV decreases mobility at the L5–S1 junction leading to biomechanical changes and altered weight distribution at this level. It is important to understand these abnormalities in the biomechanical nature of LSTV in order to determine the source of pain [7,20,22].

Some studies have evaluated the relationship between the presence of LSTV and the level of intervertebral disc degeneration [23,24]. LSTV is a relative protective factor against disc degeneration at the incomplete/complete fusion segment, while the segment above LSTV is more prone to develop LDH [24]. Luoma et al. [8] investigated the relationship between LSTV and disc degeneration in MRIs of patients with LBP. A decreased incidence of degenerative signs was noted in

Table 5. SF-36 (PF) and VAS score values amelioration during follow-up examination

	p-value	Mean difference
VAS score		
Preop–1 mo	<0.001	45.00
1 mo–3 mo	<0.001	25.00
3 mo–6 mo	<0.001	10.00
6 mo–12 mo	<0.001	10.00
12 mo–2 yr	<0.001	10.00
2 yr–5 yr	0.009	10.00
SF-36 (PF)		
Preop–1 mo	<0.001	–32.50
1 mo–3 mo	<0.001	–15.00
3 mo–6 mo	<0.001	–4.00
6 mo–12 mo	<0.001	–1.50
12 mo–2 yr	<0.001	–1.00
2 yr–5 yr	<0.001	–1.00

SF-36, Short-Form 36; PF, physical function; VAS, Visual Analog Scale; Preop, preoperative.

Table 6. Castellvi classification system and types of LSTV

Castellvi type	Definition–morphology of LSTV
I	Dysplastic transverse process (>19 mm wide). (A: unilateral, B: bilateral)
II	Incomplete lumbarization/sacralization. Enlarged transverse process–pseudoarthrosis with the adjacent sacra ala. (A: unilateral, B: bilateral)
III	Complete lumbarization/sacralization. Enlarged transverse process–fusion with the adjacent sacra ala. (A: unilateral, B: bilateral)
IV	Mixed (combination of types IIA and IIIA)

LSTV, lumbosacral transitional vertebrae.

the annulus fibrosus of the disc below the LSTV, while the endplates or nuclear complex did not demonstrate decreased degenerative changes [8]. Elster noted that a disc bulge was 9 times more common at the intervertebral disc above the LSTV than at any other level [25]. This is a consequence of hypermobility and altered stresses that become concentrated in the level just above the LSTV [25]. Additionally, the authors noted that patients with LSTV had a greater incidence of LDH impacting three or more intervertebral disc levels [6,24]. Jin et al. [7] reported that the prevalence of LSTV was far greater in the LDH group than in the control group, with an odds ratio (OR) of 3.06. This effect can be compared with the consequence of adjacent level degeneration following lumbar fusion surgery. Among patients with LSTV, the incidence of L4–L5 disc herniation was higher than that of L5–S1 disc herniation [7]. In a retrospective cohort study, patients with BS had 2.69 times higher OR of having a high disc grade at the adjacent level (L4–L5), compared with patients without BS [26]. In our study, we noted that LDH was more common in the adjacent level (L4–L5) just above LSTV, with an incidence of 72.1% of patients, while the incidence of LDH was 27.9% in cases at the same level with LSTV. While evaluating the side of LSTV and the side of LDH, Li et al. [27] concluded that 75.9% of LDH presented on the same side of LSTV and 81.8% of those cases occurred at the upper one adjacent intervertebral disc of LSTV. In this study, we evaluated whether LDH in patients with LSTV types of IA, IIA, and IIIA occurred on the contralateral or ipsilateral sides. Our findings suggested that the side of LDH was contralateral to the side of LSTV in most cases (61.7%).

Treatment options for BS range from conservative measures, such as physical therapy and pain management trials, to surgery for refractory cases [4,28,29]. Specifically concerning surgical technique, resection of the pseudo articulation leads to restoration of biomechanics in the lumbosacral junction (a semi normal state) in combination with neural decompression [23]. In a related study, Ju et al. [14] reported favorable surgical outcomes in patients with Castellvi types I and II after transverse-processectomy. Another surgical option is fusion across the level of the LSTV [2]. Fusion may result in long-lasting pain alleviation, but it may also accelerate degeneration of nearby segments. Fusion may be recommended in patients with multilevel degenerative changes (adjacent segments) or the existence of mechanical segmental instability [2]. In cases where the disc above the LSTV is intact, but the transitional disc is degenerated, fusion may be advised [19]. In the case of a symptomatic central canal or foraminal stenosis, a decompressive procedure can also be performed. In contrast to fusion, resection of a pseudo articulation may be preferred in patients with relatively healthy adjacent segments [19]. Golubovsky et al. [22] reported that the optimal surgical technique may depend on the status of the motion segments cephalad to the LSTV. Additionally, the authors concluded that fusion causes increased stress at the cephalad segments, which may contribute to more rapid degeneration [22].

Only a few studies have presented clinical outcomes for patients with LSTV and LDH who underwent microdiscectomy. Ahn et al. [9] evaluated the outcomes related to back and leg pain and quality of life, using VAS, the Oswestry Disability Index (ODI), and the 12-item Short Form Health Survey (SF-12) scores in patients with LSTV and LDH after discectomy. The VAS score for leg and back pain decreased significantly after surgery, but back pain intensity worsened at 12 and 24 months postoperatively. In addition, ODI and the physical and mental components of SF-12 worsened at 12 and 24 months postoperatively. These findings demonstrate that back pain following lumbar discectomy results in an associated deterioration of functional status as measured by ODI and general quality of life (SF-12) [9]. In a retrospective study, Shen et al. [30] presented the safety and efficacy of full-endoscopic lumbar discectomy for treating LDH in patients with LSTV. At the final follow-up (1 year), the VAS score was significantly improved, and patients demonstrated high satisfaction. Nevertheless, the presence of LSTV was reported to be a significant risk factor for recurrent disc herniation [30]. In addition, it was emphasized that LSTV was found in 52.4% of the patients in the recurrent group [30].

In our study, we evaluated the SF-36 and VAS scores during sequential follow-up intervals. As seen in the SF-36 and VAS scores, clinical assessment revealed a rapid and notable improvement of HRQoL immediately postoperatively, with a plateau of clinical improvement at 6 months postoperatively. All aspects of the VAS and SF-36 scores showed a statistically significant improvement in the 3 months following surgery and a less pronounced improvement in between 3 and 6 months postoperatively. In addition, there was statistically significant improvement in these parameters at every follow-up assessment when compared with the previous assessment. However, our study has some limitations. First, it was a retrospective, non-blinded study, second, it was not a randomized, controlled trial, and third, microdiscectomies were performed by only one surgeon.

Multiple surgeons, in multiple centers, may provide more representative results. Given these constraints, future studies should focus on these issues, in addition to potentially implementing a longer follow-up period of 10 years with more self-reported outcome measures.

Conclusions

This study demonstrated the relationship between LDH and LSTV in patients with BS. This is the first study, to the best of our knowledge, that mentions the prevalence of each type of LSTV according to the Castellvi classification system, the side of LSTV compared to the side of LDH, and the level of LDH in patients undergoing microdiscectomy. In this study, all patients underwent microdiscectomy and demonstrated favorable clinical outcomes (functional recovery and pain relief) and notable improvement of HRQoL during a 5-year follow-up period. However, additional studies with larger population sizes and longer-term follow-up are required to corroborate these results, and a comparative analysis between LDH with LSTV and LDH without LSTV could be included in future studies.

Key Points

- The lumbosacral transitional vertebrae (LSTV) in patients with Bertolotti syndrome (BS) cause alterations in the biomechanics of the lumbosacral junction.
- Patients with LSTV and BS who underwent microdiscectomy demonstrated favorable clinical outcomes (functional recovery and pain relief) and notable amelioration of Health-Related Quality of Life during a 5-year follow-up analysis.
- Microdiscectomy is a safe and effective technique in the surgical management of patients with lumbar disc herniation and BS.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Author Contributions

Conception and design: SK, KG, NG, CC. Analysis and interpretation of data: SK, KG, NG, CC. Drafting the article and critical revision of article for important intellectual content: SK, KG, NG, CC. Final approval of the version to be published and agreement to be accountable for all aspects of the work: SK, KG, NG, CC.

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