Research Article

In Silico Approach for SAR Analysis of the Predicted Model of DEPDC1B: A Novel Target for Oral Cancer

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With the incidence rate of oral carcinogenesis increasing in the Southeast-Asian countries, due to increase in the consumption of tobacco and betel quid as well as infection from human papillomavirus, specifically type 16, it becomes crucial to predict the transition of premalignant lesion to cancerous tissue at an initial stage in order to control the process of oncogenesis. DEPDC1B, downregulated in the presence of E2 protein, was recently found to be overexpressed in oral cancer, which can possibly be explained by the disruption of the E2 open reading frame upon the integration of viral genome into the host genome. DEPDC1B mediates its effect by directly interacting with Rac1 protein, which is known to regulate important cell signaling pathways. Therefore, DEPDC1B can be a potential biomarker as well as a therapeutic target for diagnosing and curing the disease. However, the lack of 3D model of the structure makes the utilization of DEPDC1B as a therapeutic target difficult. The present study focuses on the prediction of a suitable 3D model of the protein as well as the analysis of protein-protein interaction between DEPDC1B and Rac1 protein using PatchDock web server along with the identification of allosteric or regulatory sites of DEPDC1B.

1. Introduction

The association of cervical carcinomas with human papillomaviruses (HPVs), a group of small DNA viruses, was first recognized by Meisels et al. [1, 2]. Apart from being associated with cervical carcinomas, human papillomaviruses, particularly type 16, were found to be one of the major causes of oral squamous cell carcinoma (OSCC), which is the sixth most common cancer worldwide [3–5].

At a molecular genetic level, the high risk HPV 16 positive oral squamous cell carcinomas are known to express the E6 and E7 gene products which are recognized for their oncogenic potential. The E6 gene product tends to either associate with p53, forming a stable complex to promote the proteolytic degradation of p53, or downregulate the activity of effective p53 via targeting CBP/p300 (transcriptional coactivator) and therefore interferes with its function and deregulates the cell cycle [6–8]. In addition, E7 protein binds to a tumor suppressor protein, pRb, resulting in the activation of E2F (transcription factor) which further stimulates the expression of proteins critical for DNA replication [9, 10]. Normally, this unprepared onset of S-phase results in the initiation of apoptosis via p53, which, however, will not be initiated in the case of HPV infected cells owing to p53 inactivation by the viral E6 protein [11]. The regulation of the E6 and E7 gene products is mediated by another viral protein, E2. E2 is known to interact with and downregulate several proteins (CPB2, HSPBAP1, RBM26, etc.), one of them being DEPDC1B, which recently was found to be overexpressed in oral cancer [16, 17]. This can be possibly explained by the disruption of the E2 ORF upon the integration of viral
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Figure 1: Regulatory mechanism involved in the action of DEPDC1B leading to invasion/metastasis, before (a) and after (b) the integration of viral genome into the host genome, resulting in the disruption of E2 ORF, followed by oral carcinogenesis.

2. Materials and Methods

2.1. Retrieval of the Primary Sequence of DEPDC1B. The primary sequence of the protein, DEPDC1B (529 amino acid residues and 61.77 Kda in size) (UniProt ID: Q8WUY9), was obtained from UniProt (http://www.uniprot.org/) [38] in FASTA format.

2.2. Template Selection of DEPDC1B and Homology Modeling. Multiple 3D models of the protein were developed and its energy minimized with the help of Swiss model (http://swissmodel.expasy.org/) [29–32], where the best model (Figure 2) was selected out of all, followed by its sequence alignment (Figure 3) which showed a sequence similarity of 23.97% with the template, that is, the GTPase-activation domain of RhoGAP (Homo sapiens), sequestered from RCSB PDB (PDB ID: 1RGP) [39, 40]. Additionally, pairwise structural alignment between the template and the modeled target protein was performed in order to predict structural similarity between the two, using the server FATCAT (Figures 4(a) and 4(b)) [33].
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2.3. Visualization and Model Validation. The structure of the protein was predicted by Swiss modeling and visualized using PyMol version 1.3 [41], followed by the validation of the 3-dimensional structure using SAVES (http://services.mbi.ucla.edu/SAVES/), where the stereochemical quality of the 3D model obtained was verified using a program PROCHECK [42, 43] for the purpose of selecting the best model. VERIFY 3D structure evaluation server [44, 45] was used for 3D-profil ing of the residues, ERRAT [35] for the verification of the structure. To evaluate the quality of the predicted 3D model of DEPDC1B, the stereochemical quality of the 3D structure was predicted via Swiss modeling and visualized using PyMol (Figure 2), wherein it was observed that the protein structure was predicted. 2.4. Retrieval of 3D Model of the Rac1. The structure file of the protein (PDB ID: 1RGP) [48] was retrieved by the RCSB PDB in the PDB format and was then used for studying the protein-protein interaction between the two proteins. 2.5. Docking Study. Docking of DEPDC1B with the Rac1 protein was conducted using the web server PatchDock/firedock (http://bioinfo3d.cs.tau.ac.il/PatchDock) (Figure 6) [49, 50], an online tool for protein docking designed for the purpose of the identification of the interaction sites between the two, wherein the molecular surface of the protein is divided into patches as per the molecular shape followed by the comparison between the patches in order to produce a group of transformations. These transformations are then ranked as per the geometric complementarity score and each transformation is assigned with a PatchDock score as well as atomic contact energy. Finally, the atomic dissolution energy of the derive complex is estimated and the redundant solution was rejected using 1.5 Å root-mean-square-deviation, that is, RMSD, clustering during the docking process [49, 51, 52].

2.6. Active Site and Accessible Area Analysis. In order to have a better understanding of the interaction between the proteins DEPDC1B and Rac1, it becomes crucial to have a knowledge of the active site, the region in a protein that allows a protein to bind to a specific protein, of DEPDC1B (Figure 8). Additionally, active site of the template was predicted as well, in order to check for the preservation of structural similarity between the target and the template protein (Figure 4(c)). Protein Allosteric and Regulatory Sites (PARS), an online server (http://bioinf.uab.cat/cgi-bin/pars-cgi/pars.pl), was utilized for the purpose of identifying and characterizing the active site of the 3D model of DEPDC1B protein and the template, GTPase-activation domain of RhoGAP (Hom sapiens) [34].

3. Results and Discussion

For the purpose of targeting a protein therapeutically it is central to understand the structural characteristics of the protein under study. However, the absence of the 3D model of the DEPDC1B protein makes it challenging to understand its structural and functional features. Therefore, to have a better understanding, 3D model of DEPDC1B is predicted in the study predicted using Swiss model and visualized using PyMol (Figure 2), wherein it was observed that the protein consists of six α helices. Pairwise structural alignment of the predicted model and the selected template indicated that the two structures were 20.97% identical and 33.06% similar, suggesting that the two structures are significantly similar (Figure 4(a)). Figure 4 also illustrates the superimposition of template (grey in color) upon the modeled target protein, DEPDC1B (red in color) (Figure 4(b)). Interestingly, the comparison between Figure 4(b) obtained via superimposition of template upon DEPDC1B and Figure 4(c), depicting the possible active sites present in the template (PDB ID: 1RGP),
Align pdb1.pdb 189 with pdb2.pdb 124
Twists 0 ini-len 104 ini-rmsd 0.72 opt-equ 109 opt-rmsd 0.40 chain-rmsd 0.72 score 290.77
Block 0 afp 13 score 290.77 rmsd 0.72 gap 17 (0.14%)

Chain 1: 116 LPAVILKTFLRELPEPLLTFDLYPHVYGFLNI--DESQVPATLQLTQLPEENYQVLRAFLTAFLVQISA
Chain 2: 270 DVFKTADYVGLKKEPLLTFHLCFAVSLQKREAVAEFQICCLLLPEHRRKLQLLMRMARICL

Figure 4: Depiction of (a) pairwise structural alignment between the template (chain 1) and modeled target protein, DEPDC1B (chain 2); (b) superimposition of template (grey) upon the target protein (red), using FATCAT [33]; and (c) active site prediction of template using PARS [34].

Figure 5: Ramachandran plot generated using RAMPAGE, indicating the amino acid residues in the favorable region [35].

indicated great similarity; that is, the most potential active site (red in color) in the template, CAV_4.Z (p value: 0.02 and structural conservation: 100, depicted in Table 1), was found to be structurally conserved in the protein DEPDC1B as implemented in the superimposed region. Table 1 depicts the p value and structural conservation of the other predicted regulatory or allosteric active site in the template. The model generated was then validated using PROCHECK, wherein 89.4% of the total amino acid residues were found to be present in the favorable region along with 9.7% of the amino acid residues in the generously allowed region and 0.9% that is only one residue (Thr288) being in the disallowed region which can be ignored. On the contrary, the Ramachandran plot generated using RAMPAGE indicated the presence of 115 amino acid residues that is approximately 94.3% in the favorable region, 7 amino acid residues (5.7%) in the allowed region, and no residue in the outlier region, indicating good quality of the protein structure (Figure 5). Also, the VERIFY 3D results showed that an average 3D-1D score of 45.97% of the total residues was greater than or equal to 0.2, indicating a good environmental profile of the model. The model had a good environmental profile as the Z-score was found to be −0.161. An ideal model must have the average Z-score close to "0"; therefore the predicted 3D
Figure 6: Docking interaction between DEPDC1B (light grey) and Rac1 (yellowish golden) visualized by chimera [36] and docking done using PatchDock server.

Figure 7: Interacting amino acid residues between DEPDC1B (red) and Rac1 (pink) visualized using LigPlot Plus [37]; the image has been illustrated as two halves (a) first half and (b) second half.
model lies quite close to the ideal model. Further, DEPDC1B has been found to directly interact with [17] Rac1 protein, thereby mediating a downstream signaling process involved in oral carcinogenesis. A docking study was performed to understand the protein-protein interaction using the web server PatchDock/firedock (Figure 6), which showed a high docking score of −16.17 (global energy, i.e., binding energy of the solution), indicating a spontaneous interaction between the two and the interacting amino acid residues were found to be Asp270-Glu62, Glu328-Tyr32, Arg336-Tyr64, and so forth (Figure 7). The identification of the interacting or the functionally important amino acid residues will help the researchers to modify the function of the protein and thereby design/develop drugs that are highly efficient and specific for the target protein. Additionally, the understanding of protein-protein interaction (DEPDC1B-Rac1 protein interaction) will enable the researchers to further identify the pathways mediated via DEPDC1B, specifically associated with the disease, that is, oral cancer, and thereby predict its function, consequently, allowing the development of improved strategies to extirpate oral cancer. Also, active site and accessible surface area analysis was done using PARS, and the regions with the highest possibility of being regulatory or allosteric sites were identified and marked as shown in Figure 8. Table 2 lists the possible allosteric or regulatory sites which have been ranked according to their potential of regulating the function of DEPDC1B protein, on the basis of flexibility $p$ value (indicating the possibility with which a site may alter overall protein flexibility) and structural conservation, wherein the estimation of structural conservation within the protein done via PARS followed the LIGSITE$^{csc}$ pocket identification method (an extension of LIGSITE, where csc stands for Connolly surface and conservation) [34]. Based on the analysis done CAV$_{1,Z}$ site with a flexibility $p$ value of 0.07 and structural conservation of 54.60 had the highest potential of being a possible regulatory site as it fulfilled the criteria based on both flexibility $p$ value and structural conservation and CAV$_{7,Z}$ had the lowest potential as it had structural conservation of only 18.20. Also, CAV$_{8,Z}$ site shows relevant values for both criteria, that is, “0” flexibility $p$ value and structural conservation of 63.60. The 3D structure and active site prediction shall help the researcher to design a pharmacophore in order to get a drug which interacts at the site and also the identification of the amino acid residues shall help the researcher to probably design mutants of the protein which shall be able to interact with higher or lower affinity which can help hugely in the downstream signaling study.

### 4. Conclusion

Oral cancer, the sixth most commonly occurring human cancer [5] with 90% of it being oral squamous cell carcinoma [53], often preceded by the precancerous lesions such as leukoplakia and erythroplakia [54], has high prevalence in Southeast Asian countries including India due to the consumption of tobacco as well as betel quid [55]. The major challenge is the prediction of the transition from premalignant form to carcinogenic form [56].

DEPDC1B is recently found to be overexpressed in oral cancer and is capable of mediating anchorage-independent growth of oral cancer cells and promoting cell growth and invasion by interacting with Rac1 protein [17], making it a potential proteomic based biomarker as well as a therapeutic target for the purpose of curing the disease. However, due to absence of 3D structure of the protein, the structural and functional characterization of the protein becomes challenging. In order to have a detailed understanding of its role in oral cancer, the present study focused on predicting the 3D model of the protein DEPDC1B by taking RhoGAP

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**Table 1:** Values indicating potential allosteric or regulatory sites of the template (PDB ID: 1RGP), estimated using the server PARS [34].

| Rank | Site ID | Flexibility p value | Structural conservation |
|------|---------|---------------------|------------------------|
| 1    | CAV$_{4,Z}$ | 0.02               | 100.00                 |
| 2    | CAV$_{5,Z}$ | 0.00               | 100.00                 |
| 3    | CAV$_{1,Z}$ | 0.03               | 36.40                  |
| 4    | CAV$_{2,Z}$ | 0.79               | 9.30                   |
| 5    | CAV$_{3,Z}$ | 0.70               | 0.00                   |
| 6    | CAV$_{7,Z}$ | 0.53               | 54.60                  |
| 7    | CAV$_{6,Z}$ | 0.83               | 9.10                   |
| 8    | CAV$_{8,Z}$ | 0.12               | 18.20                  |

**Table 2:** Values indicating potential allosteric or regulatory sites of the target protein, DEPDC1B, estimated using the server PARS [34].

| Rank | Site ID | Flexibility p value | Structural conservation |
|------|---------|---------------------|------------------------|
| 1    | CAV$_{1,Z}$ | 0.07               | 54.60                  |
| 2    | CAV$_{8,Z}$ | 0.00               | 63.60                  |
| 3    | CAV$_{6,Z}$ | 0.03               | 18.20                  |
| 4    | CAV$_{2,Z}$ | 0.38               | 9.10                   |
| 5    | CAV$_{3,Z}$ | 0.64               | 18.20                  |
| 6    | CAV$_{4,Z}$ | 0.21               | 9.10                   |
| 7    | CAV$_{5,Z}$ | 0.07               | 9.10                   |
| 8    | CAV$_{7,Z}$ | 0.07               | 18.20                  |

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**Figure 8:** Potential allosteric or regulatory sites in the predicted model of DEPDC1B. Cyan colored pocket representing the structurally conserved sites and orange colored pockets representing the ones that affect the flexibility. Sites matching both criteria are marked red [34].
as the template structure with the help of Swiss model, which as per the results was close to the ideal model and had a good environmental profile. Apart from the structural characterization of a protein, it is of utmost importance to understand and identify the binding partners of the protein implicated in a disease, in this case interaction of DEPDC1B with other proteins, such as Rac1, as it allows the researchers to deduce/further predict and enhance our knowledge regarding the functional characteristics of the target protein. Rac1 which is known to play a crucial role in the onset of oral carcinogenesis, by regulating cell cycle, contact inhibition, cellular growth, and proliferation mediated via NFκB activation [23–26], indicates the possible pathway through which DEPDC1B initiates oral carcinogenesis. Further, the active site and accessible surface area analysis via PARS focused on the identification of the sites with the highest potential of being regulatory or allosteric sites, in order to therapeutically target the protein by specifically modifying or targeting the identified sites, wherein CAV_1^Z (Figure 8) was marked as the allosteric/regulatory site with the highest potential. The sites with moderate or less potential can also be further analyzed.

Therefore, by predicating the 3D model of DEPDC1B, the present study was able to identify the interacting amino acid residues of the protein DEPDC1B with the Rac1, through which DEPDC1B regulates the transition of a normal cell to a malignant one. Also, the identification of the possible allosteric or regulatory sites enhances our knowledge and thereby will play a crucial role in designing an appropriate drug that will have the potential of targeting the protein DEPDC1B and therefore curing the disease, that is, oral cancer.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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